NOTICE

All drawings located at the end of the document.

6-11-91

Enclosed SOPs

FO 4, Rev 1
FO 5, Rev 1
FO 6, Rev 1
FO 7, Rev 1
FO 8, Rev 1
FO 9, Rev 1
FO 10, Rev 1
FO 14, Rev 1

GT 1, Rev 1
GT 2, Rev 1
GT 4, Rev 1
GT 6, Rev 1
GT 10, Rev 1
GT 15, Rev D
GT 17, Rev D
GT 18, Rev Ø, D
GT 19, Rev Ø, FD

Also included are the EPA review comments.

Enclosed SOP's:

FO.2, Rev.0
FO.3, Rev.0
FO.4, Rev.1
FO.5, Rev.1
FO.6, Rev.1
FO.7, Rev.1
FO.8, Rev.1
FO.10, Rev.1
FO.11, Rev.0
FO.12, Rev.0
FO.13, Rev.0
FO.14, Rev.1
FO.15, Rev.0
FO.16, Rev.0

GW.3, Rev.0

GT.1, Rev.1
GT.2, Rev.1
GT.3, Rev.0
GT.4, Rev 1
GT.5, Rev.0
GT.6, Rev.1
GT.10, Rev.1
GT.15, Rev.D
GT.17, Rev.D
GT.18, Rev.0,D
GT.19, Rev.0,FD

This volume comprises SOP's required for initiation of field operations. Bold versions in the above list have been recently revised or drafted in response to DOE and/or EPA comments.

Please reference SOP's dated February 1991 for FO.2, Rev. 0; F.O. 3, Rev. 0; F.O. 11, Rev. 0; F.O. 12, Rev 0; F. O. 13, Rev. 0; F.O. 15, Rev. 0; F.O. 16, Rev. 0; GW.3, Rev. 0; GT3, Rev. 0; GT5, Rev. 0

REVIEWED FOR CLASSIFICATION/UCNI
By [signature]
Date 10/28/91

DOCUMENT REVIEW COMMENT RECORD

DOCUMENT REVIEWED Rocky Flats Plant Site-wide Standard Operating Procedures, Final Version, March 1991

DOCUMENT REVIEWER Environmental Protection Agency Region VIII

Date May 24, 1991

CITATION	COMMENT	DISPOSITION
Attachment 1 Volume 1 Field Operations	Conditions of Approval	
<u>General</u>	As indicated in our comments on the draft, this volume is not complete with SOPs for sampling and analysis of bulk wastes, drums, structures, and equipment, and surveying and mapping of sampling points These SOPs are still missing, and must be added before this volume can be approved	Sampling of bulk wastes, drums, etc is not applicable to the current drilling program, but will be addressed at a later date (i e with regard to sampling of trenches) An SOP for land surveying has been written and is submitted for your review
	The potential for confusion still exists among the various definitions provided for "potentially contaminated" vs "not potentially contaminated" which must be eliminated For example, SOP 1 10, Section 6 0, lists and illustrates IHSS's and other specific areas considered contaminated and those surface water and sediment sampling stations "verified as background stations" It then states that "unless specified in the individual project work plans, all other work areas will be considered potentially contaminated " Other SOPs in this volume (see 1.4) apparently consider all areas not specifically characterized as potentially contaminated to be <u>not</u> potentially contaminated A comprehensive listing and/or a map must be prepared and included to show contractors, without question, where the "potentially contaminated" procedures specified are required	SOP 1 10 accurately reflects the distinction between potentially and <u>not</u> potentially contaminated work areas Appendix A (SOP 1 10) is a complete listing of the IHSS's as specified in the IAG Wording in SOP FO 4 (formerly SOP 1 4) has been revised to eliminate the confusion The IHSS reference list and location map have also been added to SOP FO 4 as an appendix

DOCUMENT REVIEW COMMENT RECORD

DOCUMENT REVIEWED Rocky Flats Plant Site-wide Standard Operating Procedures, Final Version, March 1991
DOCUMENT REVIEWER Environmental Protection Agency Region VIII Date May 24, 1991

CITATION	COMMENT	DISPOSITION
SOP 1.1	This SOP has evidently not been reviewed by or coordinated with the person(s) preparing the PPCD, as it contradicts current procedures as reflected in the interim PPCD The SOP ends with dust measurements and Hi and Lo-Vol sampling, it and/or related Air SOPs (to be prepared) must specify what will be done with these samples, and establish the decision process for determining appropriate control measures based on the sample analysis results, coordination with the final PPCD preparation will be essential, to ensure consistency	As agreed at the May 22, 1991 meeting, the IPPCD will suffice for current drilling operations SOP 1 1 is currently being revised to address agency concerns and will be complete by July 31, 1991
SOP 1.5	Examination of Sections 6 1 and 6 2 indicates purge and development water will be dumped on the ground unless field monitoring indicates contamination This is not appropriate, as the field monitoring does not detect all compounds of concern This (and related) SOP(s) must be changed to require that purge and development water originating in potentially contaminated areas be containerized and handled on the assumption that it is contaminated, regardless of field monitoring results A full characterization of this material must be performed to identify and support proper ultimate disposal Similarly, the SOP must require all equipment used in potentially contaminated areas be decontaminated according to SOP 1 3, not only when positive readings are obtained, as stated in Section 7 0	Purge and development water will be contained and transported to the decontamination facility for disposal into liquid holding tanks SOP 1 5 (FO 5) has been revised to reflect this A full characterization will not be necessary because these liquids will be disposed in the liquid holding tanks This SOP has also been revised to require decontamination of all equipment used in potentially contaminated work areas

DOCUMENT REVIEW COMMENT RECORD

DOCUMENT REVIEWED Rocky Flats Plant Site-wide Standard Operating Procedures, Final Version, March 1991

DOCUMENT REVIEWER Environmental Protection Agency Region VIII Date May 24, 1991

CITATION	COMMENT	DISPOSITION
SOP 1 8	Using the same logic as for purge and development water, all cuttings and drilling fluids derived from operations in potentially contaminated areas must be handled as if they are contaminated, regardless of field monitoring results, until a full waste characterization proves otherwise This (and related) SOP(s) must be revised to reflect this requirement	Drill cuttings will be contained in gray 55-gallon drums and left at the site If the characterization of associated samples comes back negative, the cuttings will be dispersed within 50 feet of the originating borehole If the characterizations show the presence of contaminants, a subcontractor will move the associated drums to the transfer area where the drums will be painted, labeled and transferred to the custody of waste operations personnel for storage and/or disposal
SOP 1 13	The geotechnical SOP (3 2) indicates this is where we should find instructions for sub-sampling of cores, which we specifically noted as a missing item in our previous comments (on draft SOP 3 2, Section 5 3 1) The three items enumerated there [(1) the criteria and procedures used to select sampling intervals, (2) procedures for removal and preparation of sub-samples for extractable organics analysis, which should not be composited, and (3) provisions for taking VOA samples from other than the pre-targeted interval based on core examination and field testing] have not been added, and must be	Plant-wide sampling criteria for VOC characterization has been added to SOP GT 2 (formerly SOP 3 2)

DOCUMENT REVIEW COMMENT RECORD

DOCUMENT REVIEWED Rocky Flats Plant Site-wide Standard Operating Procedures, Final Version, March 1991
DOCUMENT REVIEWER Environmental Protection Agency Region VIII Date May 24, 1991

CITATION	COMMENT	DISPOSITION
SOP 1.14	This SOP includes the data forms submitted for database entry However, it does not adequately indicate the need for air monitoring data forms The section should include forms for air monitoring data	The sample form that is completed by the Environmental Monitoring and Assessment Technician (EMAT) at the time of pulling the air filter has been added to this SOP This form is completed and submitted to the lab along with the sample for analysis No additional forms are utilized due to the electronic transfer of data between the lab and Air Programs (via the RFP Vax System)
SOP 1 15	The Draft OU 2 Phase II (Bedrock) Work Plan references this and/or SOP 3 9 as the locations for procedures covering use of a portable GC as a site characterization tool Very little such information is found in either SOP, as they deal predominantly with PID/FID use During revisions, the SOPs and the associated SOPA must be expanded to provide a complete description of the equipment and procedures for portable GC use	A new procedure is being developed Pertinent features of the portable GC will be included Procedures for obtaining standards will be addressed, however, targeted compounds are project-specific and will be determined by the project manager
	This should include, but not be limited to 1 Instrument(s), model and pertinent features such as isothermal oven, 2 Compounds for which standards will be prepared, and procedures for preparation or commercial sources, 3 Standard and conditional intervals for running machine and sampling train blanks, and 4 Procedures for preventing/purging contamination, particularly cross-contamination between consecutive samples	Running blanks and calibrations will also be addressed Prevention and purging of contamination will be addressed

DOCUMENT REVIEW COMMENT RECORD

DOCUMENT REVIEWED Rocky Flats Plant Site-wide Standard Operating Procedures, Final Version, March 1991

DOCUMENT REVIEWER Environmental Protection Agency Region VIII

Date May 24, 1991

CITATION	COMMENT	DISPOSITION
Volume II Groundwater SOP 2 1, Section 5 1	The section describes the calculation for groundwater elevation in a monitoring well It is generally confusing, and sometimes incorrect For instance, it states the measuring point (MP) correction converts the measurement to a distance above or below land surface the correction actually convert the measurement to a common reference point, such as mean sea level. The remainder of the SOP requires revision to eliminate inconsistent and confusing instructions and terminology such as overlapping use of the terms "measuring point" and "reference point" within the text	This SOP is not applicable to the current drilling program and therefore, will not be addressed at this time SOP 2 1 will be revised in the near future
Volume III Geotechnical SOP 3 1, General	As indicated in our comments on the draft, this volume is not complete without SOPs for selection and use of geophysical techniques Several of the work plans submitted and under development rely heavily on the use of both surface (GPR, EM, etc) and down-hole (Gamma, neutron, etc) techniques for site characterization These techniques are by their nature prone to misuse and misinterpretation Geophysical SOPs are still missing, and must be added before this volume can be considered complete	SOPs for downhole geophysical logging and surface GPR and EM surveys are submitted for your review
	While it is true that geological reconnaissance studies require considerable professional judgement and successful completion relies heavily on experience and insight, adherence to standardized methods can minimize errors and reduce the need for relogging All field personnel must be consistent in following the sample procedures for characterizing alluvial and bedrock materials Also, training programs must be set up to educate and familiarize field personnel with the procedures presented or referenced in this volume	Training for all SOPs is required by the QAPjP Training sessions are specifically required in 3 1 under "Responsibilities and Qualifications" prior to allowing anyone involved with characterizing alluvial and bedrock materials to begin work

DOCUMENT REVIEW COMMENT RECORD

DOCUMENT REVIEWED	Rocky Flats Plant Site-wide Standard Operating Procedures, Final Version, March 1991
DOCUMENT REVIEWER	Environmental Protection Agency Region VIII — Date May 24, 1991

CITATION	COMMENT	DISPOSITION
	Referring again to our comments on the draft, the SOPs still do not contain any mention of the "second hole" drilling technique, nor provide any procedure for drilling in high-hazard areas, both of which were previously promised The SOPs must be revised, or new ones added, to cover these two issues	EG&G will not twin wells to obtain core except possibly for VOCs in an organic clay (see SOP GT 2, formerly SOP 3 2) Alluvial/Bedrock paired wells are specifically addressed in individual workplans Procedures for drilling in high-hazard areas are addressed specifically, area by area, in the Health and Safety Plans Volume I of the SOPs deals with all field operations (decon, handling of fluids, cuttings, residual samples) associated with work in hazardous areas
<u>SOP 3.1, Section 5 2</u>	Bedrock material is to be characterized using procedures and techniques described in the "Manual of field Geology" by Compton (1962) This SOP must describe in detail the procedures to be followed or the referenced document must be mandatory logging equipment in the field	SOP 3 1 <u>does</u> describe in detail the procedures to be followed These procedures are modeled after Compton and hence the reference The beginning statement has been modified to correctly reflect this
	This discussion must include a description of if and/or how a core reference set or similar tactic will be utilized to facilitate consistent lithologic descriptions Also, some confusion exists on grain size scales This SOP compares the different grain size scales, but does not state clearly which one is to be used, it must be revised to do so	Loggers have been trained using a core-reference set, which describes the different lithologies that will be encountered at RFP Core reference sets will be a reference guide only The geologist will use the same descriptive terminology and rock type determinations on all lithologic logs This will help to ensure consistency among logging geologists

DOCUMENT REVIEW COMMENT RECORD

DOCUMENT REVIEWED Rocky Flats Plant Site-wide Standard Operating Procedures, Final Version, March 1991
DOCUMENT REVIEWER Environmental Protection Agency Region VIII

Date May 24, 1991

CITATION	COMMENT	DISPOSITION
		The U S C S classification system is to be used at RFP The beginning sentence in Section 5 1 has been modified to state such explicitly
SOP 3.4, Section 7 0 Form 3 4A	The following technical information must be entered into the log - Core length - Core loss - Percent of recovery - Core breakage due to discontinuities - Total core breakage - Rock classification and lithology	This SOP (now GT 4) has been revised to state that all necessary information for rock cores will be recorded on the Borehole Log Form GT 1 in SOP GT 1
SOP 3 6, Section 5 3 2 1	This section must state that protective casing will not be placed until the well passes plumbness and alignment tests, standards for which must be included here	This SOP (now GT 6) has been revised to incorporate plumbness and alignment tests prior to setting protective casing
Volume 4 Surface Water SOP 4.8	The pond sampling SOP must discuss provisions for sampling light or dense nonaqueous phase liquids (LNAPL or DNAPL) which may be present in surface water Currently, the SOPs do not consider the possibility of LNAPLs or DNAPLs and the potential for LNAPLs or DNAPLs in ponds at Rocky Flats cannot be ignored. The previous comment on this subject was not addressed in the revised SOP	This comment will be addressed in the near future It is not applicable to the current drilling program

DOCUMENT REVIEW COMMENT RECORD

DOCUMENT REVIEWED Rocky Flats Plant Site-wide Standard Operating Procedures, Final Version, March 1991
DOCUMENT REVIEWER Environmental Protection Agency Region VIII Date May 24, 1991

CITATION	COMMENT	DISPOSITION
Volume 5 Ecology General	The contents of this document are generally adequate and fully explanatory, although none discuss procedures for determining sample size, sample location, statistical procedures, or other considerations that will be left to the field sampling plan EPA believes that in conjunction with the Environmental Evaluation Workplans to be prepared for each OU, the Ecology SOPs represent a workable field document This is based on the assumption that field personnel would have appropriate knowledge and experience in conducting ecological studies in similar areas and conditions The SOPs are not consistent in the requirement of 40 hour health and safety training for field personnel, in compliance with 29 CFR 1910 120 Some SOPs state field personnel "should" have the training and some say field personnel "must" have the training For work on RFP, this training must be required The SOPs do not discuss the possible existence of threatened, endangered, or other special status species on RFP and protocols to be implemented if any of these species are encountered. To be effective for field use, the SOPs must alert the field team members of the special nature of these organisms and the limitations on activities required to avoid harming them	The Ecology SOPs (Volume 5) were revised per EPA and CDH comments and forwarded to DOE on May 21, 1991
Volume 6 Air General	OPs 6 1 through 6.7 cover EMADs stack-sampling procedures. These are not relevant to the ER program and do not belong here. SOPs 6.8 through 6 11 are apparently missing, as the next one provided is numbered 6 12. In short, the only relevant SOP we have for air is for preventative maintenance of Hi-Vol samplers. A number of others need to be developed (in coordination with the Final PPCD) to complete this set. These must include but not be limited to:	The Air SOPs (Volume 6) are not required for the current drilling program. The entire volume is currently being revised and drafts will be completed by July 31, 1991

DOCUMENT REVIEW COMMENT RECORD

DOCUMENT REVIEWED Rocky Flats Plant Site-wide Standard Operating Procedures, Final Version, March 1991

DOCUMENT REVIEWER Environmental Protection Agency Region VIII — Date May 24, 1991

CITATION	COMMENT	DISPOSITION
	• Placement, design, installation, and operation of meteorological monitoring stations, • Placement, design, installation, and operation of particulate <u>and</u> air toxics monitoring stations, • Instrument calibration and maintenance, • Collection, handling, reduction, and reporting of meteorological and air quality data, and • Site-specific particulate <u>and</u> air toxic monitoring procedures at active investigation/sites	

HEAVY EQUIPMENT DECONTAMINATION

EG&G ROCKY FLATS PLANT	**Manual:**	**5-21200-OPS**
EMAD MANUAL OPERATION SOP	**Procedure No.:**	**FO 4, Rev. 1**
	Page	**1 of 21**
	Effective Date:	**June 10, 1991**
Category 2	**Organization:**	**Environmental Management**

TITLE
HEAVY EQUIPMENT
DECONTAMINATION

Approved By:

______________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIXES

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes the procedures and equipment that will be used at the Rocky Flats Plant (RFP) to remove contaminants that may accumulate on heavy equipment This SOP is applicable to all operations conducted as part of the Environmental Management (EM) Program

This SOP describes the equipment and procedures required to complete decontamination of heavy equipment

3.0 RESPONSIBILITIES AND QUALIFICATIONS

EG&G Radiation Protection Technicians (RPTs) or RPT designated representatives will perform radiation screening of all personnel and equipment leaving a work area Screening will be performed in accordance with EG&G Radiological Operation Instruction 3 1 and screening procedures will follow Section 6 3, Contamination Monitoring of this SOP For radiologically contaminated equipment, radiation screening will be performed following each field decontamination procedure until the equipment is free of radiological contamination or the decision is made to seal the contaminated area and transport the equipment to the central decontamination station All radiologically contaminated heavy equipment transported to the central decontamination station will be screened by the RPTs or RPT designated representatives following decontamination

The subcontractor's project manager is responsible for ensuring that appropriate project staff and equipment are assigned to implement field decontamination, transport, and final decontamination of heavy equipment used by that subcontractor The subcontractor's Site Safety Officer is responsible for performing Volatile Organic Compound (VOC) contamination screening of heavy equipment in accordance with the procedures given in Section 6.3, Contamination Monitoring, of this SOP The subcontractor's Site Safety Officer is also responsible for performing radiological monitoring during contaminant reduction of heavy equipment in the field

All personnel operating heavy equipment or company vehicles must have appropriate training and licenses

4.0 REFERENCES

4.1 SOURCE REFERENCES

<u>A Compendium of Superfund Field Operations Methods</u> EPA/540/P-87/001 December 1987

<u>Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities</u> NIOSH/OSHA/USCG/EPA October 1985

<u>Nuclear Weapon Accident Response Procedures (NARP) Manual</u> The Defense Nuclear Agency January 1984 Change 1, July 1984.

<u>Standard Operating Safety Guides</u> EPA November 1984

<u>Technical Enforcement Guidance Document</u> (TEGD) EPA 1986

4.2 INTERNAL REFERENCES

Related SOPs and EG&G Radiological Operating Instructions (ROI) cross-referenced in these procedures are as follows

- SOP FO 3, General Equipment Decontamination
- SOP FO 7, Handling of Decontamination Water and Washwater
- SOP FO 8, Handling of Drilling Fluids and Cuttings
- SOP FO 10, Receiving, Labeling, and Handling Waste Containers
- SOP GT 1, Performance of Surface Contamination Surveys

5.0 EQUIPMENT REQUIRED

5.1 CONTAMINATION REDUCTION IN THE FIELD

At the work site, contamination reduction will be accomplished by using the following items

- Spatula
- Stiff bristle brushes
- Long-handled shovel
- Plastic sheeting
- Absorbent wipes
- Containers for potentially contaminated media
- A trailer and tow vehicle to transport heavy equipment from work areas known or suspected of containing surficial contamination to a central decontaminating station Procedures to limit the spread of contamination during transport are provided in Subsection 6 4

Contamination monitoring will be accomplished using the following instruments

- Radiation detection equipment
- Organic Vapor Detector (OVD) (Hnu or equivalent)

5.2 MAIN DECONTAMINATION FACILITY

The most effective results will be obtained at a fixed decontamination station with provisions for ensuring that wash and rinse solutions rapidly drain away from the equipment being decontaminated and are containerized Numerous equipment items and supplies must be furnished from various sources for the Main Decontamination Facility (MDF) to function as intended The equipment listed below has been divided into two sections "Equipment Provided At The MDF" and "Equipment Provided By MDF Users"

Equipment And Supplies Provided At The MDF

- Drains, pumps, and tanks for the collection and holding of decontamination and rinse solutions
- High pressure steam cleaner and high pressure wash and rinse systems
- Sufficient potable water to be used in the high pressure cleaning systems
- Portable power generator
- Splash curtains
- Wooden pallets
- A back-hoe or equivalent heavy equipment item outfitted with a "drum grappler"
- A two wheeled "dolley" designed to carry 55-gallon drums
- Overpacks to be used in the event a waste container is dropped or otherwise damaged and starts to spill wastes
- Opaque, water proof sheeting
- Plastic or nylon banding and the equipment necessary to band the sheeting to waste containers

- Long and short-handled stiff bristle brushes

- Wire brushes

- Wash and rinse buckets for equipment interiors

- Premoistened towelettes

- Duct tape or equivalent

- Windsock or equivalent method for decontamination workers to determine the wind direction

Equipment And Supplies Provided By MDF Users

- Personal protective equipment (PPE) as required by the site-specific Health and Safety Plan

- Waste containers for used PPE, non-reusable items required to complete decontamination, and soils dislodged during decontamination

- An OVD to screen equipment and waste containers for an estimate of the effectiveness of decontamination efforts

- Radiation detection equipment

- Wash and rinse buckets necessary to establish a personal decontamination line identical to the one used at the work-site that resulted in contamination of the items being decontaminated

- Any equipment of task-specific decontamination fluids required by a SOP or SOPA but that are not listed as being available at the MDF

- Blank waste container labels to replace any completed labels that become dislodged or rendered unledgible during the decontamination process

- In addition, MDF users are responsible for arranging to have an EG&G RPT or RPT designated representative present if required

6.0 PROCEDURES

6.1 INTRODUCTION

Each project work area will be characterized by EG&G prior to any field activity Work area characterizations will be based on the historical background of the work area and include the chemical results of previous soil and groundwater analyses and the results of field radiological surveys conducted by EG&G RPTs or RPT designated representatives Work areas associated with the EM program field operations fall into two characterizations potentially contaminated and not potentially contaminated. Work areas currently characterized as potentially contaminated include the following:

- Individual Hazardous Substance Sites (IHSSs)
- Identified Groundwater Plume Areas
- Americium Zone at OU No 2
- Surface water and sediment sampling stations that have not been verified as background locations

Potentially contaminated work areas where groundwater plumes have been identified will be specified in the applicable work plans, as appropriate Table FO 4-A1 of Appendix FO 4A lists the

IHSS work areas at RFP and Figure FO 4-A1 shows the locations of the IHSSs Figure FO 4-1 illustrates the identified groundwater plume areas and the americium area at OU No 2. Table FO 4-1 lists the surface water and sediment stations (locations) that have been verified as background stations (uncontaminated) as of December, 1990 Other surface and sediment sampling stations will be added to this list as they become verified as background stations Unless specified in the individual project work plans, all other work areas will be considered potentially contaminated and the procedures described in this SOP will be followed

Heavy equipment used in a work area characterized as not potentially contaminated but where environmental monitoring conducted as the work progresses indicates the presence of contamination may also become contaminated Since such contamination is not always easily discernible, it is necessary to assume that all equipment working an area, where the presence of such substances are known or suspected, has been contaminated Effective decontamination procedures as described in this SOP will be implemented to minimize the potential for cross-contamination, offsite contaminant migration, and personnel exposure from improperly decontaminated equipment

Heavy equipment used in an activity area characterized by EG&G as not potentially contaminated and where environmental monitoring conducted as the work progresses does not indicate the presence of contamination may be washed at a central decontamination station Procedures established in Section 6 0 are not applicable, but Form FO 4A, Heavy Equipment Decontamination/Wash Checklist and Record, Sections I, II, and III (Attachment 1), shall be completed

6.2 CONTAMINATION REDUCTION IN THE FIELD

Although the most effective decontamination will generally be accomplished at a dedicated decontamination station, it is always desirable to accomplish a reduction in overall contamination in the field prior to moving equipment to a dedicated decontamination station The goal of contamination reduction is to limit contaminant migration from the exclusion zone Contamination

TABLE FO.4-1

BACKGROUND SURFACE WATER AND SEDIMENT STATIONS FOR ROCKY FLATS PLANT

Surface Water Station Number	Sediment Station Number	Location
SW004	SED 22	Rock Creek Drainage
SW005	SED 20	Rock Creek Drainage
SW006	SED 23	Rock Creek Drainage
SW108	SED 21	Rock Creek Valley Wall
SW007	SED 04	Tributary of Walnut Creek
SW041	SED 17	Tributary of Woman Creek
SW080	SED 18	Tributary of Woman Creek (spring)
SW104	SED 19	Tributary of Woman Creek (spring)
SW107	SED 16	Woman Creek Drainage
SW042	SED 15	Offsite Gravel Pits

Draft Background Geochemical Characterization Report
Rocky Flats Plant, Golden, Colorado
rockwell\bkgdchem\sed-3a jbb

reduction will occur near the work site within the exclusion zone

Contamination reduction is accomplished by scraping, brushing, or otherwise removing as much obvious accumulation of the potentially contaminated media as possible After the potentially contaminated media has been removed, monitoring will be accomplished by the subcontractor's Site Safety Officer The subcontractor's Site Safety Officer will use procedures established in EG&G Radiological Operation Instructions (ROI) 3 1, Performance of Surface Contamination Surveys, to conduct radiation monitoring during contamination reduction activities in the field Sections 10 3 and 10 4 of the referenced ROI relate specifically to conducting monitoring of potentially contaminated heavy equipment during contamination reduction activities in the field If monitoring indicated the presence of contamination, the contaminated areas will be wiped with heavy-duty premoistened towelettes (i e , baby wipes) if doing so may reduce contamination Following wipe down with the premoistened towelettes, the area will be remonitored The preceding sequence of actions will be repeated until monitoring indicates that no further reduction in contamination is occurring The contaminated area will then be sealed as described in Subsection 6 4. and the type, amount, and location of contamination recorded on Form FO.4A The completed Form FO 4A will accompany the equipment and be provided to the individual responsible for completing decontamination at the main decontamination facility.

In the event disposal equipment is not available and equipment must be re-used immediately; as in the case of continuous samplers core butes, etc , a field decontamination may be set up outside the exclusion zone A field decontamination will including the following procedures

- Scrape gross contamination from equipment while in the exclusion zone

- Remove the item to be decontaminated from the exclusion zone and wash in a laboratory grade detergent and tap water A brush may be used for residual particulates

- Rinse the item in tap water

- Triple rinse the item in tap water

- Equipment may now either be wrapped in plastic to prevent cross-contamination or be reused immediately

Substances removed during the contamination reduction process shall be handled as described in SOP FO 7, Handling of Decontamination Water and Wash Water, SOP FO 8, Handling of Drilling Fluids and Cuttings, and SOP FO 10 Receiving, Labeling, and Handling Waste Containers.

6.2.1 Prework Activities

Limiting the amount of surfaces exposed to potential contamination is an effective method of reducing contamination The following steps will be taken each time heavy equipment is to be used in any manner that has potential for resulting in the equipment becoming contaminated

Once an item of heavy equipment has been taken into a potentially contaminated area, it will not normally be removed from the work area until all work that requires the presence of the equipment has been completed Therefore care should be taken to ensure that fuel, oil, hydraulic fluid, and lubricant reservoirs are filled prior to entering the work area For example, if "X" amount of monitoring wells are to be constructed within a given work area, then the drill rig being used will not leave the area until all drilling has been completed Of course, augers and other like items will have to be decontaminated between bore holes In order to reduce the potential for contamination of internal operating parts, heavy equipment will be removed from potentially contaminated areas and decontaminated if it becomes necessary to perform any maintenance on the equipment that may result in contamination of internal operating parts

If an enclosed cab is present, it will be lined with plastic sheeting As a minimum, the seat(s) and floor will be covered, and the sheeting secured in such a manner that it will not become dislodged during routine use

After arriving at a work site, any compartments, tool boxes, and enclosed cabs shall be sealed by closing the doors and windows when such fixtures are present and sealing the seams around such fixtures with tape

When at the work site, any fuel, oil, or hydraulic fluid fill ports and air cleaners will be sealed in a manner that blocks the entrance of dusts that may be radiologically contaminated unless to do so would disable a power system required to complete the field work

6.3 CONTAMINATION MONITORING

Monitoring for potential VOC contamination and potential radiological contamination will be conducted on all heavy equipment used inside work areas characterized as potentially contaminated and on all heavy equipment used inside work areas characterized as not potentially contaminated but where environmental monitoring conducted as work progresses indicates the presence of contamination

EG&G RPTs or RPT designated representatives will screen all equipment and personnel leaving the work area to ensure that no radioactively contaminated materials leave the work area. The RPT will use procedures established in EG&G Radiological Operation Instruction (ROI) 3 1, Performance of Surface Contamination Surveys

The subcontractor's health and safety representative assigned to the field team will monitor all personnel and equipment to ensure that no materials grossly contaminated with VOCs leave the area

Special attention shall be devoted to tires, tracks, and any other surfaces that have been in direct contact with the environmental media being investigated or that have been in direct contact with other items of equipment or personnel that have been in direct contact with the environmental media being investigated Special attention shall also be devoted to any surfaces where accumulations of the environmental media being investigated exist

6.4 MOVEMENT OF CONTAMINATED HEAVY EQUIPMENT

A trailer will be required to move equipment to a central decontamination station if contamination monitoring indicates contamination on surfaces such as tires or tracks or any other item which may contact the ground or become dislodged when the equipment is moved. Any trailer used to move heavy equipment to a central decontamination station will be decontaminated and the effectiveness of decontamination verified in the same manner as the equipment it was used to move

Following field contamination reduction, equipment surface areas remaining contaminated shall be covered with plastic sheeting prior to the equipment departing the exclusion zone Edges of the sheeting will be held in place by duct tape or a similar type tape

Contaminated heavy equipment will not be moved at speeds greater than 5 miles per hour Heavy equipment will not be moved over paved roads during the hours of peak traffic flow, such as the beginning or end of the work day

6.5 CENTRAL DECONTAMINATION STATION

The central decontamination station is located adjacent to and south of the 903 Pad Information regarding the configuration, operation, and maintenance of the central decontamination station has been prepared and may be found in SOP FO 12, Decontamination Facility Operations The following procedures are presented in the chronological order in which they should normally occur

6.5.1 Predecontamination Procedures

- Review Form FO 4A, Heavy Equipment Decontamination Checklist and Record to determine the level of PPE required by the applicable site-specific health and safety plan and the correct decontamination procedure

- Establish a personnel decontamination line as described in the applicable site-specific health and safety plan

- Personal protective equipment (PPE) will be used as required in the applicable Health and Safety Plan

- Upon arrival at the MDF, the equipment to be decontaminated and any accompanying waste containers will be set on the ground at locations that will permit one item or group of similar items at a time to be placed within the screened-in portion of the MDF

- If radiological monitoring during the contamination reduction process documented the suspected presence of radioactive substances that could not be removed during the contamination reduction process, arrangements will be made for an EG&G RPT or RPT designated representative to verify the effectiveness of decontamination

- Areas that have been sealed against exposure to the environment as required by this SOP, (due to the suspected presence of contamination that could not be removed during the contamination reduction process at the work area) will be clearly marked so that the area can be identified and monitored

- Surfaces suspected of having tightly bound contamination that could not be removed during the contamination reduction process will be decontaminated first Procedures specified in this SOP will be followed The MDF user will use an OVD or radiation monitor as appropriate to screen the surfaces suspected of having had tightly bound contamination If the screening indicates the contamination has been removed, the equipment will be moved out of the MDF and returned to service only if the type of contamination that had previously been suspected was organic contamination If the presence of radioactive contamination was suspected, the equipment will be moved out of the MDF, parked nearby, and held out of service until verification of decontamination as described in Subsection 6 4 1, Verification of Decontamination, has occurred

- Verification of effectiveness of decontamination is not required for heavy equipment surfaces that were found to be contaminant free by monitoring at the work area conducted as part of the contamination reduction process

6.5.2 Decontamination Procedures

- Enclosed cabs

  - Remove plastic lining/covers and dispose as contaminated waste

  - Wipe down interior surfaces

  - Use a brush to apply a detergent and water solution to the floor

  - A low-pressure water hose should be used to flush the detergent and water solution from the cab

  - Seal the cab by closing doors, windows, and vents

- Engine compartments

  - Although engines should not normally become contaminated, the engine area will be visually inspected for signs (e g , mud splashes) of potential contamination

  - Any dry air filters servicing equipment used in a solid waste management unit will be removed and handled as radiologically contaminated waste

  - If there are not any signs of contamination, the compartment should be left as is and sealed during decontamination of exterior surfaces

  - If there appears to be contamination present, someone familiar with the engine will employ the procedures for decontaminating exterior surfaces while avoiding damage to moisture-sensitive engine components Moisture-sensitive components may be covered with plastic during engine decontamination The components will then be hand wiped with disposable moistened towels, following general engine decontamination

  - Following engine decontamination, the engine compartment should be sealed during decontamination of exterior surfaces

- Exterior surfaces including trailers used to move equipment to the decontamination station

  - Inspect equipment and trailers for obvious accumulation of contaminated media that can be easily dislodged by physical means (see Subsection 6 2, Contamination Reduction in the Field)

  - Use a pressurized detergent and water solution, followed by a pressurized potable water rinse

- Stand upwind/crosswind of the surface being decontaminated If necessary the equipment will be reoriented inside the decontamination station to allow an upwind or crosswind position, or hand brushing will be used to complete decontamination

- Start at the uppermost surface and work downward including the underside of the equipment

- Pay particular attention to areas such as tires that came into contact with a potentially contaminated media and areas that show visual signs of contamination such as mud splashes on the inside of fenders or accumulations of water in a bed

- Move the equipment and decontaminate the equipment surfaces that have been in contact with the decontamination station floor.

- Arrange for an EG&G RPT or RPT designated representative to conduct a smear test as described in ROI 3 1, Performance to Surface Contamination Surveys, to verify removal of radiological contamination if such contamination had been noted on the Form FO 4A when the equipment arrived Repeat the decontamination procedures for exterior surfaces if radiological contamination is found and then repeat the monitoring If contamination is still present after completing the second decontamination procedure, contact the appropriate EG&G Construction Manager

- Equipment

  - Items which come into direct contact with environmental samples collected for laboratory analysis will be decontaminated as described in SOP FO.3, General Equipment Decontamination Examples of such items are sample containers

- Equipment used inside contaminated activity areas but that do not directly contact samples will be decontaminated by a pressurized detergent and water solution followed by a pressurized potable water rinse Examples of such items include augers, drilling rods, and any hand tools used during drilling Decontamination will be verified as described in Subsection 6 4.3, Post Decontamination Procedures

6.5.3 Post Decontamination Procedures

- Equipment surfaces that could not be decontaminated in the field during contamination reduction activities will undergo verification of decontamination at the MDF Verification of organic decontamination will be accomplished with an OVD by the MDF user responsible for decontaminating the equipment Verification of radiological decontamination will be accomplished by an EG&G RPT or RPT designated representative using the instruments and techniques specified in ROI 3 1, Performance of Surface Contamination Surveys

- Decontaminate brushes and other reusable items of decontamination equipment as described in SOP FO.3, General Equipment Decontamination

- Complete personal decontamination as described in the applicable site-specific health and safety plan

- Document decontamination using Form FO 4A, Heavy Equipment Decontamination Record

- SOP FO 7, Handling of Decontamination Washwater, provides pertinent guidance which should be followed

7.0 DOCUMENTATION

Form FO 4A, Heavy Equipment Decontamination Record, shall be used to document information required by this SOP Completed forms will be maintained as part of the project files Sections I and II of the form will be completed by the person delivering heavy equipment for decontamination Sections III, IV, and V will be completed by the person conducting the decontamination operation

APPENDIX FO.4A

APPENDIX FO.4A

TABLE FO 4-A1
ROCKY FLATS PLANT
INDIVIDUAL HAZARDOUS SUBSTANCE SITES

REF. NO.	SITE NAME
101	207 SOLAR EVAPORATION PONDS
102	OIL SLUDGE PIT
103	CHEMICAL BURIAL
104	LIQUID DUMPING
105	OUT-OF-SERVICE FUEL TANKS
	105 1 - WESTERNMOST TANK
	105 2 - EASTERNMOST TANK
106	OUTFALL
107	HILLSIDE OIL LEAK
108	TRENCH T-1
109	TRENCH T-2
110	TRENCH T-3
	TRENCHES T-4 TO T-11
	111 1 TRENCH T-4
	111 2 TRENCH T-5
	111 3 TRENCH T-6
	111 4 TRENCH T-7
	111.5 TRENCH T-8
	111 6 TRENCH T-9
	111 7 TRENCH T-10
	111 8 TRENCH T-11
112	903 DRUM STORAGE AREA
113	MOUND AREA
114	PRESENT LANDFILL
115	ORIGINAL LANDFILL
116	MULTIPLE SOLVENT SPILLS
	116 1 WEST LOADING DOCK AREA
	116 2 SOUTH LOADING DOCK AREA

Note This information is based on the administrative record including the information submitted in the hazardous and low-level mixed waste Part B application dated November 1, 1985, as modified by the subsequent revision dated November 28, 1986, as modified by the subsequent revision dated December 15, 1987, and the transuranic mixed waste Part B application submitted July 1, 1988, Thereafter referred to as the applications This information is also based on independent review of historical aerial photographs of the facility and independent review of facility submittals

Table FO 4-A1 (cont)

INDIVIDUAL HAZARDOUS SUBSTANCE SITES

REF NO.	SITE NAME
117	CHEMICAL STORAGE
	117 1 NORTH SITE
	117 2 MIDDLE SITE
	117.3 SOUTH SITE
118	MULTIPLE SOLVENT SPILLS
	118 1 WEST OF BUILDING 731
	118 2· SOUTH END OF BUILDING 776
119	MULTIPLE SOLVENT SPILLS
	119 1 WEST AREA
	119 2 EAST AREA
120	FIBERGLASSING AREAS
	120 1 NORTH OF BUILDING 664
	120 2. WEST OF BUILDING 664
121	ORIGINAL PROCESS WASTE LINES
122	UNDERGROUND CONCRETE TANK
123	VALVE VAULT 7
	123 1· VALVE VAULT 7 4,000 GALLON TANK #67)
125	HOLDING TANK
126	OUT-OF-SERVICE PROCESS WASTE TANKS
	126 1. WESTERNMOST TANK
	126 2. EASTERNMOST TANK
127	LOW-LEVEL RADIOACTIVE WASTE LEAK
128	OIL BURN PIT NO 1
129	OIL LEAK
130	RADIOACTIVE SITE - 800 AREA SITE #1
131	RADIOACTIVE SITE - 700 AREA SITE $1
132	RADIOACTIVE SITE - 700 AREA SITE #4
133	ASH PITS
	133 1.ASH PIT 1-1
	133 2 ASH PIT 1-2
	133 3 ASH PIT 1-3
	133 4 ASH PIT 1-4
	133 5 INCINERATOR
	133 6 CONCRETE WASH PAD
134	LITHIUM METAL DESTRUCTION SITE

Table FO 4-A1 (cont)
INDIVIDUAL HAZARDOUS SUBSTANCE SITES

REF NO	SITE NAME
135	COOLING TOWER BLOWDOWN
136	COOLING TOWER PONDS
	136 1 NORTHEAST CORNER OF BUILDING 460
	136 2 WEST OF BUILDING 460
	136 3 S OF BLDG 460, W OF BLDG 444
137	COOLING TOWER BLOWDOWN - BLDG 774
138	COOLING TOWER BLOWDOWN - BLDG 779
139	CAUSTIC/ACID SPILLS
	139 1 HYDROXIDE TANK AREA
	139 2. HYDROFLUORIC ACID TANKS
140	REACTIVE METAL DESTRUCTION SITE
141	SLUDGE DISPERSAL
142	RETENTION PONDS (A,B,C-SERIES)
	142 1 A-1 POND
	METAL DESTRUCTION SITE
141	SLUDGE DISPERSAL
142	RETENTION PONDS (A,B,C-SERIES)
	142 1 A-1 POND
	142 2 A-2 POND
	142.3 A-3 POND
	142.4 A-4 POND
	142 5 B-1 POND
	142 6 B-2 POND
	142 7 B-3 POND
	142.8 B-4 POND
	142.9 B-5 POND
	142 10 C-1 POND
	142 11 C-2 POND
	142 12 NEWLY IDENTIFIED A-5 POND
143	OLD OUTFALL
144	SEWER LINE BREAK
145	SANITARY WASTE LINE LEAK
146	CONCRETE PROCESS WASTE TANKS
	146 1 7,500 GALLON TANK (#31)
	146 2 7,500 GALLON TANK (432)
	146 3 7,500 GALLON TANK (*34W)
	146 4 7,500 GALLON TANK (#34E)
	146 5 3,750 GALLON TANK (*30)
	146 6 3,750 GALLON TANK (#33)

Table FO 4-A1 (cont)
INDIVIDUAL HAZARDOUS SUBSTANCE SITES

REF NO	SITE NAME
147	PROCESS WASTE LEAKS 147 1 MAAS AREA
	147.2 OWEN AREA
148	WASTE SPILLS
149	EFFLUENT PIPE
150	RADIOACTIVE LIQUID LEAKS (8)
	150 1 NORTH OF BUILDING 771
	150 2 WEST OF BUILDING 771
	150 3 BETWEEN BUILDINGS 771 ant 774
	150 4 EAST OF BUILDING 750
	150 5 WEST OF BUILDING 707
	150 6 SOUTH OF BUILDING 779
	150 7 SOUTH OF BUILDING 776
	150 8 NORTHEAST OF BUILDING 770
151	FUEL OIL LEAK
152	FUEL OIL TANK
153	OIL BURN PIT NO 2
154	PALLET BURN SITE
155	903 LIP AREA
156	RADIOACTIVE SOIL BURIAL
	156 1 BUILDING 334 PARKING LOT
	156 2. SOIL DUMP AREA
157	RADIOACTIVE SITE
	157.1· NORTH AREA
	157.2: SOUTH AREA
158	RADIOACTIVE SITE - BLDG 551
159	RADIOACTIVE SITE - BLDG 559
160	RADIOACTIVE SITE - BLDG 444 PK LOT
161	RADIOACTIVE SITE - BLDG 664
162	RADIOACTIVE SITE - 700 AREA SITE #2
163	RADIOACTIVE SITE - 700 AREA SITE #3
	163 1 WASH AREA
	163 2 BURIED SLAB
164	RADIOACTIVE SITE - 800 AREA SITE #2
	164 1 CONCRETE SLAB
	164 2 BUILDING 886 SPILLS
	164 3 BUILDING 889 STORAGE PAD
165	TRIANGLE AREA

TABLE FO 4-A1 (cont)
INDIVIDUAL HAZARDOUS SUBSTANCE SITES

REF NO	SITE NAME
166	TRENCHES
	166 1 TRENCH A
	166 2 TRENCH B
	166.3 TRENCH C
167	SPRAY FIELDS - THREE SITES
	167 1 NORTH AREA
	167 2 POND AREA
	167 3 SOUTH AREA
168	WEST SPRAY FIELD
169	WASTE DRUM PEROXIDE BURIAL
170	P U & D STORAGE YARD - WASTE SPILLS
171	SOLVENT BURNING GROUND
172	CENTRAL AVENUE WASTE SPILL
173	RADIOACTIVE SITE - 900 AREA
174	P U &D CONTAINER STORAGE FACILITIES (2)
175	S&W BLDG 980 CONTAINER STORAGE FACILITY
176	S&W CONTRACTOR STORAGE YARD
177	BUILDING 885 DRUM STORAGE AREA
178	BUILDING 881 DRUM STORAGE AREA
179	BUILDING 865 DRUM STORAGE AREA
180	BUILDING 883 DRUM STORAGE AREA
181	BUILDING 334 CARGO CONTAINER AREA
182	BUILDING 444/453 DRUM STORAGE AREA
183	GAS DETOXIFICATION AREA
184	BUILDING 991 STEAM CLEANING AREA
185	SOLVENT SPILL
186	VALVE VAULT 12
187	ACID LEAKS (2)
188	ACID LEAK
189	MULTIPLE ACID SPILLS
190	CAUSTIC LEAK
191	HYDROGEN PEROXIDE SPILL
192	ANTIFREEZE DISCHARGE
193	STEAM CONDENSATE LEAK
194	STEAM CONDENSATE LEAK
195	NICKEL CARBONYL DISPOSAL
196	WATER TREATMENT PLANT BACKWASH POND
197	SCRAP METAL SITES

TABLE FO 4-A1 (cont)
INDIVIDUAL HAZARDOUS SUBSTANCE SITES

REF NO	SITE NAME
198	VOCs IN GROUND WATER
199	CONTAMINATION OF THE LAND SURFACE
200	GREAT WESTERN RESERVOIR
201	STANDLEY RESERVOIR
202	MOWER RESERVOIR
203	INACTIVE HAZARDOUS WASTE STORAGE AREA
204	ORIGINAL URANIUM CHIP ROASTER
205	BLDG 460 SUMP 43 ACID SIDE
206	INACTIVE D-836 HAZARDOUS WASTE TANK
207	INACTIVE 444 ACID DUMPSTER
208	INACTIVE 444/447 WASTE STORAGE AREA
209	SURFACE DISTURBANCE SOUTHEAST OF BLDG 881
210	UNIT 16, BUILDING 980 CARGO CONTAINER
211	UNIT 26, BUILDING 881 DRUM STORAGE
212	UNIT 63, BUILDING 371 DRUM STORAGE
213	UNIT 15, 904 PAD PONDCRETE STORAGE
214	UNIT 25, 750 PAD PONDCRETE AND SALTCRETE STORAGE
215	UNITS 55 13, 55 14, 55.15, 55 16 - TANKS T-40, T-66, T-67, T-68
216	EAST SPRAY FIELDS
	216 1 NORTH AREA
	216 2 CENTER AREA
	216 3 SOUTH AREA
217	UNIT 32, BUILDING 881, CN- BENCH SCALE TREATMENT

HEAVY EQUIPMENT DECONTAMINATION/WASH CHECKLIST AND RECORD

I General Information (completed by ______________________________________)

name date phone no

____

Subcontractor's Name

NOTE Sections I and II will be completed by the same individual

Vehicle Manufacturer, Model and Common Name ______________________

Equipment Owner ______________________________________

Name and Phone Number of Person Responsible for the Equipment ______________

Serial Number/Vehicle Identification Number (VIN) ______________________

Delivered to Decontamination Station by ______________________________

Initial contaminate characterization of activity area ______________________

Equipment delivered to Central Decontamination Station on a trailer due to VOC or radiological contamination _______ Yes _______ No

Were areas found to be contaminated covered with plastic sheeting taped in-place prior to movement? _______ Yes _______ No _______ No contamination present

II Exposure History

Where was equipment used? ______________________________________

What was equipment used for? ______________________________________

Did verified environmental monitoring indicate the presence of contamination? __ Yes __ No

Name of person who accomplished environmental radiological monitoring in the field

____

Name Date Phone No Employer's Name

Results of Radiological monitoring of equipment after final contamination reduction in the field

_____ None detected

_____ Less than 250 cpm - Specify measured cpm __

_____ Greater than 250 cpm - Specify measured cpm ___

If areas of measurable alpha radiation were found, clearly identify those areas by providing both a written description sufficient to enable a second party to locate the area and include a sketch of the area showing its location in relation to major components of the equipment being decontaminated

Results of VOC monitoring after final contamination reduction in the field

_____ VOCs at background levels

_____ VOCs greater than background

III Actions At Central Decontamination Station

Yes	No	
___	___	The equipment was washed under the provisions of SOP No FO 4, Heavy Equipment Decontamination, Subsection 6 1
___	___	Personnel Decontamination Station established as described in the applicable site-specific health and safety plan
___	___	Personal protective equipment (PPE) selected based upon results of radiological monitoring
___	___	Specify PPE level utilized _____ Level B _____ Level C _____ Level D
___	___	PPE inspected prior to donning
___	___	Wind direction checked prior to using pressurized spray (circle the direction the wind was blowing from) N NE E SE S SW W NW
___	___	Enclosed cab present and decontaminated
___	___	Engine compartment inspected and decontaminated as required
___	___	Were decontamination and rinse operations started at the uppermost surfaces?
___	___	Was particular attention devoted to areas such as tires that contacted a potentially contaminated medium and to areas identified as having a measurable level of alpha radiation?
___	___	Was the equipment moved to decontaminate surfaces that had been in contact with the decontamination station floor?
___	___	Was equipment used to decontaminate the heavy equipment decontaminated as described in SOP FO.3, General Equipment Decontamination?
___	___	Was personal decontamination completed as described in the applicable site-specific health and safety plan?

IV Equipment Monitoring to Verify Removal of Contamination

Name of EG&G RPT or RPT designated representative conducting smear test as described in ROI 3 1,

Performance of Surface Contamination Surveys ______________________________

(Name) (Date) (Phone No)

Results of smear test ______________________________

Name of person conducting VOC monitoring

____

(Name) (Date) (Phone No) (Subcontractor's Name)

Results of VOC monitoring ______________________________

V Follow-up Decontamination

___ Not Required

___ Required for the following area/surfaces

____

____

____

Results of follow-up smear test ______________________________

___ Decontamination completed

___ Decontamination incomplete and EG&G Construction Manager notified

(______________________)

Name Date Phone No

EG&G ROCKY FLATS PLANT	**Manual:**	**5-21200-OPS**
EMAD MANUAL OPERATION SOP	**Procedure No.:**	**FO 5, Rev. 1**
	Page:	**1 of 8**
	Effective Date:	**June 10, 1991**
Category 2	**Organization:**	**Environmental Management**

TITLE
HANDLING OF PURGE AND DEVELOPMENT WATER

Approved By

______________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes the procedures that will be used for containing, moving, and emptying wastewater generated during well development at the Rocky Flats Plant (RFP)

3.0 RESPONSIBILITIES AND QUALIFICATIONS

Personnel using light or heavy equipment, scientific monitoring devices, or operating company vehicles must have appropriate training and/or licenses

The subcontractor's site manager is responsible for coordinating the removal and transfer of all environmental materials from the project work area

The subcontractor is also responsible for moving purge and development water to holding tanks located at the central EG&G decontamination facility

It is the subcontractor's site manager's responsibility to report as soon as possible to the EG&G project manager or a designated EG&G representative any damage incurred to a drum Types of damage include holes, damage to the lid seal, or any other problem that may compromise drum integrity Damaged drums must have their contents transferred to an undamaged drum

The subcontractor's site manager will assign personnel to conduct weekly inspections of all the drums issued to the subcontractor until relinquished to EG&G These inspections will ensure that drum integrity is maintained

EG&G's Radiation Protection Technicians (RPTs) or RPT designated representatives are responsible for conducting radiation screenings of equipment, samples, and personnel before they leave the work area

EG&G's Waste Operations personnel are responsible for the collection, movement, storage, treatment, and disposal of environmental liquids from the main decontamination facility

4 0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure

EG&G Policies Rocky Flats Plant Use and Color Coding of Drums RFPM MAT 20-005 November 3, 1989

Environmental Protection Agency (EPA). A Compendium of Superfund Field Operations Methods EPA/540/P-87/001 December 1987

RCRA Facility Investigation Guidance Interim Final May 1989

4.2 INTERNAL REFERENCES

Related SOPs cross-referenced in this SOP are

- SOP FO 3, General Equipment Decontamination
- SOP FO 7, Handling of Decontamination Water and Wash Water
- SOP FO 8, Handling of Drilling Fluids and Cuttings
- SOP FO 10, Receiving, Labeling, and Handling Environmental Materials Containers
- SOP FO 12, Decontamination Facility Operations
- SOP FO 15, Use of PIDs and FIDs
- SOP FO 16, Field Radiological Measurements

5.0 EQUIPMENT

5.1 EQUIPMENT NEEDED TO HANDLE PURGE AND DEVELOPMENT WATER

The following is a list of equipment needed for the proper handling of purge and development water

- 55-gallon, open top (removable top), gray drums or liquid containers appropriately sized for the task
- Hand, electric, or gas powered pumps
- An organic vapor detector (OVD)
- A field radiation monitor
- Shovel (scoop type)
- Clear plastic sheeting for placing around the well head to prevent cross contamination of the surface
- Splash protective and personal protective equipment as required by the site-specific Health and Safety Plan

6.0 HANDLING OF PURGE AND DEVELOPMENT WATER

Water used during the development of an environmental monitoring well is considered purge and development water Monitoring well development is the process by which the drilling fluids and mobile particulates are removed from within and adjacent to newly installed wells This process can also be used to remove sediment or other built-up materials from older wells

Each project work area will be characterized by EG&G prior to any field activity Work area characterizations will be based on the historical background of the work area and include the chemical results of previous soil and groundwater analyses and the results of field radiological surveys conducted by EG&G RPTs or RPT designated representatives Work areas associated with the Environmental Management (EM) program field operations fall into two characterizations potentially contaminated and <u>not</u> potentially contaminated Work areas currently characterized as potentially contaminated include the following

- Individual Hazardous Substance Sites (IHSSs)
- Identified Groundwater Plume Areas
- Americium Zone at OU No 2
- Surface water and sediment sampling stations that have not been verified as background locations

See SOP FO 10, Receiving, Labeling, and Handling Environmental Materials Containers for specific work areas currently characterized as potentially contaminated Appendix A (SOP FO 10) is a list of the IHSSs at RFP

Solid environmental materials generated during EM field operations will be containerized as they are generated in 55-gallon gray drums until associated samples are characterized Environmental liquids will be moved to holding tanks located at the main decontamination facility (see SOP FO 12, Decontamination Facility Operations) The use of field monitors, including an OVD and radiation monitor, for the detection of volatile organics and radionuclides is discussed in SOPs FO 8, Handling of Drilling Fluids and Cuttings, FO 15, Use of Photoionizing Detectors and Flame Ionizing Detectors, and FO 16, Field Radiological Instruments

The types of contamination which may be encountered within potentially contaminated work areas include the following·

- Low-level radioactively contaminated substances
- Nonradioactive RCRA-regulated hazardous (hazardous) substances
- Mixed (low-level radioactive and hazardous substances)

Regardless of the work area characterization, all purge and development water will be placed in the liquid holding tanks at the main decontamination facility In the field, the purge and development water will be temporarily stored in 55-gallon, open top, gray drums or appropriately sized containers Liquid containers will be marked with the words "NONPOTABLE PENDING ANALYSIS" as described in SOP FO 10, Receiving, Labeling, and Handling Environmental Materials Containers Field personnel should decant the environmental liquids from one drum (or container) to another (or from a trough to a drum or transfer container) prior to moving if the amount of sludge or sediment within the environmental liquids is substantial The residual sediment will be drummed as solid environmental materials (see SOP FO 8, Handling of Drilling Fluids and Cuttings) Characterization will be based on analytical results of the samples corresponding to the cuttings associated with the drill site

The liquid containers will be moved to EG&G's main decontamination facility by the subcontractor The decontamination facility will have an area specifically designed for environmental liquid The environmental liquids area includes a process for separating solids from the liquids The subcontractor will empty the entire container's contents into this environmental liquids area (See SOP FO 12, Decontamination Facility Operations, for details pertaining to the environmental liquids area)

The liquid containers will be decontaminated between each use If gray drums are used, pertinent information regarding the use of gray drums will be documented on the Drum Field Log Form (Form FO 10A, see Section 8 0 - Documentation)

The drums containing residual sediment will be brought to the drum transfer area at the main decontamination facility and transferred to the custody of EG&G Waste Operations personnel

Environmental liquid containers will be decontaminated between each use

7.0 DECONTAMINATION

Equipment used for the development of a monitoring well located within a potentially contaminated work area will be decontaminated according to SOP FO.3, General Equipment Decontamination If positive readings above background were detected during field monitoring within not potentially contaminated work areas, equipment will be decontaminated according to SOP FO.3

In not potentially contaminated work areas, where no verified detections were encountered during field monitoring, the equipment used will be power sprayed and rinsed

Decontamination and wash water will be disposed according to SOP FO 7, Handling of Decontamination Water and Wash Water

8.0 DOCUMENTATION

8.1 DRUM FIELD LOG FORM

A Drum Field Log Form (Form FO 10A) will be kept on each gray drum used to move environmental liquids The Drum Field Log Form will be used as a "cradle to grave" record The following information will be documented on the form

- Drum ID Number
- Date of issuance
- Location in field
- Contents
- Fill date
- Date of decontamination and location
- Date returned to EG&G

Entries made on the Drum Field Log Form may be supported with entries in a field logbook

DEPARTMENT OF ENERGY ROCKY FLATS PLANT

DRUM FIELD LOG FORM

FORM FO 10A

NAME OF THE SUBCONTRACTOR ____________________

DRUM ID NUMBER WITH SUBCONTRACTOR'S ID ____________________

LOCATION AND DATE OF ISSUANCE LOC ____________ DATE ____________

NAME AND LOCATION OF FIELD ACTIVITY NAME ____________ LOC ____________

ASSOCIATED WELL, BORING, OR SAMPLING LOCATION NAME ____________ ____________

CONTENTS OF DRUM ____________

SUBSURFACE INTERVALS (IF SOILS) ____________ ____________

BAG #S (IF PPE) ____________ ____________

ASSOCIATED SAMPLE ID #S ____________ ____________

DATE DRUM WAS FILLED ____________

SIGNATURE OF PERSON FILLING THE DRUM ____________

IF SOLID ENVIRONMENTAL MATERIALS

LOCATION OF TEMPORARY STORAGE AREA ____________

DATE DRUM RETURNED TO EG&G ____________

SIGNATURE OF EG&G REPRESENTATIVE ____________

IF ENVIRONMENTAL LIQUIDS

DATE AND LOCATION WHERE CONTENTS WERE EMPTIED AND DECONNED DATE ____________ LOC ____________

(EXAMPLE 2/18/91 DECON PAD #____)

EG&G ROCKY FLATS PLANT	Manual.	5-21200-OPS
EMAD MANUAL OPERATION SOP	Procedure No.:	FO.6, Rev. 1
	Page:	1 of 10
	Effective Date:	June 10, 1991
Category 2	Organization:	Environmental Management

TITLE·
HANDLING OF PERSONAL PROTECTIVE EQUIPMENT

Approved By:

_______________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

2.0 PURPOSE AND SCOPE

The waste generated from Environmental Management (EM) field activities will be handled in accordance with the Rocky Flats Plant (RFP) waste management program This standard operating procedure (SOP) describes procedures that will be used by subcontractors at RFP to handle waste personal protective equipment (PPE) These procedures are intended to be sufficiently detailed so that conformance with them will result in reliable handling and management of PPE used during EM field activities

3.0 RESPONSIBILITIES AND QUALIFICATIONS

Personnel using light or heavy equipment, scientific monitoring devices, or operating company vehicles must have appropriate training or licenses

The subcontractor's site manager is responsible for coordinating the removal and transfer of all wastes from the project work area

The subcontractor is responsible for drumming PPE suspected of containing radioactive and/or hazardous substances Drums containing PPE will be transferred to the custody of EG&G Waste Operations personnel only after the drum contents have been characterized Characterization will be based on analytical results of the samples corresponding to the cuttings associated with the drill site

It is the subcontractor's site manager's responsibility to report as soon as possible to the EG&G project manager or a designated EG&G representative any damage incurred to a drum Types of damage include holes, damage to the lid seal, or any other problem that may compromise drum integrity Damaged drums must have their contents transferred to an undamaged drum or be overpacked

The subcontractor's site manager will assign personnel to conduct monthly inspections of all the drums issued to the subcontractor until relinquished to EG&G These inspections will ensure that drum integrity is maintained

EG&G's Radiation Protection Technicians (RPTs) or RPT designated representatives are responsible for conducting radiation screenings of equipment, samples, and personnel before they leave potentially contaminated work areas

EG&G's Waste Operations personnel are responsible for the collection, movement, storage, treatment, and disposal of solid wastes from the drum transfer area

4.0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure

A Compendium of Superfund Field Operations Methods EPA/540/P-87/001 December 1987.

Rockwell International Policies Rocky Flats Plant, Use and Color Coding of Drums RFPM MAT 20-005 November 3, 1989

4.2 INTERNAL REFERENCES

Related SOPs cross-referenced by this SOP are as follows·

- SOP FO 10, Receiving, Labeling, and Handling Waste Containers
- SOP FO 2, Field Documentation
- SOP FO 8, Handling of Drilling Fluids and Cuttings
- SOP FO 12, Decontamination Facility Operations
- SOP FO 15, Use of Photoionizing Detectors and Flame Ionizing Detectors
- SOP FO 16, Field Radiological Measurements

5 0 EQUIPMENT

The following items will be required during most operations that generate potentially contaminated PPE

- Appropriate 55-gallon drums as described in SOP FO 10, Receiving, Labeling, and Handling Waste Containers
- Paint stick for marking drums
- Tools for opening and sealing open-top 55-gallon drums with a clamp-type sealing band
- Pallets or other method of ensuring that drums do not rest on the ground surface
- Opaque, weather-proof sheeting
- Plastic/nylon banding to secure plastic sheeting on the drums
- Large plastic garbage bags

6.0 PROCEDURES FOR HANDLING OF PERSONAL PROTECTIVE EQUIPMENT

Each project work area will be characterized by EG&G prior to any field activity Work area characterizations will be based on the historical background of the work area and include the chemical results of previous soil and groundwater analyses and the results of field radiological surveys conducted by EG&G RPTs or RPT designated representatives Work areas associated with the EM program field operations fall into two characterizations. potentially contaminated and not potentially contaminated Work areas currently characterized as potentially contaminated include the following

- Individual Hazardous Substance Sites (IHSSs)
- Identified Groundwater Plume Areas
- Americium Zone at OU No 2
- Surface water and sediment sampling stations that have not been verified as background locations

Other potentially contaminated work areas where groundwater plumes have been identified will be specified in the applicable work plans, as appropriate SOP FO 10, Receiving, Labeling, and Handling Waste Containers, lists the IHSS work areas at RFP and illustrates the identified groundwater plume areas and the americium area at OU No 2. It also lists the surface water and sediment stations that have been verified as background stations as of December 1990 Other surface and sediment sampling stations will be added to this list as they become verified as background stations Unless specified in the individual project work plans, all other work areas will be considered potentially contaminated

PPE generated during EM field operations will be handled depending on the work area characterization and the results of field monitoring performed during intrusive activities The use of field monitors for the detection of volatile organics and low-level radioactively contaminated substances is discussed in SOP FO 15, Use of Photoionization Detectors and Flame Ionization Detectors, and SOP FO.16, Field Radiological Instruments

The subcontractor's site manager is responsible for implementing waste management procedures established by this SOP and procedures referenced in this SOP

These duties include

- Consulting with the EG&G EM project manager to resolve any questions concerning the characterization of a work area

- Arranging for the pickup of gray drums

- Ensuring that potentially contaminated PPE is not commingled in a drum with solid wastes

- Ensuring all documentation and drum markings are completed properly and that a "cradle-to-grave" system of drum tracking is maintained (see SOP FO 10, Receiving, Labeling, and Handling Waste Containers)

- Conducting monthly inspections of all drums issued to the subcontractor

- Arranging for the transfer of drums to EG&G

6.1 PERSONAL PROTECTIVE EQUIPMENT

PPE is generally defined as clothing or equipment required to be worn by the site-specific Health and Safety Plan (HSP) in order to limit worker's exposure to physical, chemical or radiological health hazards Any questions regarding whether a given item is considered to be PPE for the purposes of waste disposal should be directed to the site safety officer

Potentially contaminated PPE is any PPE used in a work area characterized as potentially contaminated or PPE used in a work area characterized as not contaminated but where a verified positive reading was encountered on either the OVD or field radiation monitor during intrusive activities

In general, the site-specific HSP will describe the PPE to be worn, as well as methods of decontaminating disposable and reusable PPE, such as respirators In general, garbage cans with plastic liners are prescribed for use in the personal decontamination line to contain discarded PPE This SOP provides procedures for handling and disposing of disposable PPE

6.2 HANDLING OF PPE IN WORK AREAS CHARACTERIZED AS POTENTIALLY CONTAMINATED

6.2 1 Temporary Sampling Sites

PPE used at temporary sampling sites in work areas characterized as potentially contaminated will be considered potentially contaminated Workers will establish a personal decontamination line in accordance with the site-specific HSP and will place their PPE in containers while going through the decontamination line

The following procedures will be used to handle potentially contaminated PPE from containers used in a personal decontamination line

- If respiratory protection was required during the field activity, the last person through the decontamination line will continue to wear the respiratory protection until removal is indicated in these procedures

- The last person will process through the decontamination line just as the preceding workers

- After all PPE items have been removed and placed in the waste container, the container can be processed

- The last worker will don a fresh pair of gloves before handling the plastic bags containing PPE at the last decontamination station He will then remove the plastic bags containing the discarded PPE from the container, compress the bags in a downwind direction, seal the compressed bags with duct tape, and return the bags to the container from which they were taken

- While still wearing the respirator and the fresh pair of gloves, the worker will remove the sealed plastic bags containing PPE from the containers along the decontamination line

- Where possible, the individual bags of PPE will be combined in a single plastic bag, sealed with duct tape, and marked with a waterproof marker If it is not possible to combine individual bags into a single bag, each individual bag will be sealed and marked

- Marking for plastic bags will include the characters "PPE"; the I D number of the waste drum in which it will be stored, the associated well, boring, or sampling number and location, and the date.

- The waste bags will be placed in a designated 55-gallon drum in accordance with SOP FO.10, Receiving, Labeling, and Handling Waste Containers

- In no instance will an unmarked bag be placed in a drum

- The respirator may be removed after all PPE waste bags have been placed in appropriate drums. The respirator cartridges and gloves will also be removed and placed inside an appropriate drum

- Partially filled drums will be marked and taken to the temporary staging area at the drum transfer area

- Filled drums will be taken to the drum transfer area

- For temporary sampling sites within an IHSS, the drum staging area will be centrally located within the unit

6.2.2 Fixed Sample Sites for Site-Wide Programs

Procedures described in Subsection 6 2 1 for PPE removal, bagging, and marking will be followed to handle potentially contaminated PPE used in work areas characterized as potentially contaminated

Procedures for staging the bags of potentially contaminated PPE are as follows

- Seal and mark bags of PPE and place bags in a gray drum at the drill site until characterized

- Drums will be filled to a minimum capacity of 90 percent prior to moving to the transfer area

- The bags of PPE will be placed in the appropriate colored 55-gallon drum and labeled according to SOP FO 10, Receiving, Labeling, and Handling Waste Containers

6.3 HANDLING OF PPE IN WORK AREAS CHARACTERIZED AS NOT POTENTIALLY CONTAMINATED

PPE will be considered uncontaminated if it was used in a work area characterized as not potentially contaminated and field monitoring did not indicate the presence of potential contamination

Disposable PPE will normally be handled as ordinary waste Disposable PPE and uncontaminated miscellaneous solid wastes will be placed in garbage cans lined with plastic bags at the work area Marking is not required for bags of uncontaminated disposable PPE or bags of uncontaminated miscellaneous solid wastes When full, these plastic bags will be transferred to EG&G's custody at designated locations within the subcontractor's work areas

The procedures for handling potentially contaminated PPE will be followed if either verified positive field organic vapor monitoring or field radiation detection monitoring indicate potential contamination

7 0 DOCUMENTATION

A permanent record of the implementation of this SOP will be kept by documenting field observations and data Observations and data will be recorded on drum field log forms It is important to annotate on the drum field log form all of the sample locations and sample numbers of the activities for which these PPE were worn This information should be included in the space for intervals on the drum field log form Subcontracting personnel may also choose to document the observations and data in a personal field notebook in addition to the field log forms If a field book is used, entries should be made with a black waterproof ink pen The field notebook should be waterproofed and have consecutively numbered pages

It is recommended that the subcontractor bring duplicate copies of the completed Drum Field Log Form when transferring custody of waste drums to EG&G personnel Both copies should be signed by the receiving EG&G representative EG&G Waste Operations will retain one signed copy and the subcontractor will retain the second signed copy in the project files

Additional guidance on completing documentation for the drums is found in SOP FO 10, Receiving, Labeling, and Handling Waste Containers.

Drum field log forms will be prepared for each drum containing PPE Partial drums will be transferred to the drum staging area until they can be filled and transferred at the drum transfer area to EG&G

Drum field log forms will be kept in the subcontractor's project files until the project is completed All project files will be turned over to EG&G at this time (see SOP FO 2, Field Documentation)

Contaminant Characterization Forms will be used for the characterization of PPE that has been temporarily stored in gray drums until analytical results are received Upon receipt of the sample results for all the samples taken while the PPE was worn and therefore associated with the contents of a drum, the subcontractor will submit the drum identification portion of the form along with the analytical results to the EG&G project manager for characterization

EG&G ROCKY FLATS PLANT		**Manual:**	**5-21200-OPS**
EMAD MANUAL OPERATION SOP		**Procedure No.:**	**FO 7, Rev. 1**
		Page:	**1 of 8**
		Effective Date:	**June 10, 1991**
Category 2		**Organization:**	**Environmental Management**

TITLE
HANDLING OF DECONTAMINATION
WATER AND WASH WATER

Approved By:

_______________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes procedures that will be used by subcontractors at Rocky Flats to handle decontamination water and wash water used during Environmental Management (EM) field activities

3 0 RESPONSIBILITIES AND QUALIFICATIONS

Personnel using light or heavy equipment, scientific monitoring devices, or operating company vehicles must have appropriate training and/or licenses

The subcontractor's site manager is responsible for coordinating the removal and transfer of all solid environmental materials from the project work area

The subcontractor is also responsible for moving environmental liquids to holding tanks located at the central EG&G decontamination facility

It is the subcontractor's site manager's responsibility to report as soon as possible to the EG&G project manager or a designated EG&G representative any damage incurred to a drum Types of damage include holes, damage to the lid seal, or any other problem that may compromise drum integrity Damaged drums must have their contents transferred to an undamaged drum

The subcontractor's site manager will assign personnel to conduct weekly inspections of all the drums issued to the subcontractor until relinquished to EG&G. These inspections will ensure that drum integrity is maintained

EG&G's Radiation Protection Technicians (RPTs) or RPT designated representatives are responsible for conducting radiation screenings of equipment, samples, and personnel before they leave the work area

EG&G's Waste Operations personnel are responsible for the collection, transport, and storage of solid environmental materials from the drum transfer area and environmental liquids at the main decontamination facility

4 0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure

EG&G Use and Color Coding of Drums Policies Rocky Flats Plant RFPM MAT 20-005 November 3, 1989

Environmental Protection Agency (EPA) A Compendium of Superfund Field Operations Methods EPA/540/P-87/001 December 1987

RCRA Facility Investigation Guidance Interim Final May 1989

4.2 INTERNAL REFERENCES

Related SOPs cross-referenced in this SOP are as follows

- SOP FO.3, General Equipment Decontamination
- SOP FO 4, Heavy Equipment Decontamination
- SOP FO 8, Handling of Drilling Fluids and Cuttings
- SOP FO 10, Receiving, Labeling, and Handling Environmental Materials Containers
- SOP FO 12, Decontamination Facility Operations
- SOP FO 18, Use of Photoionizing Detectors and Flame Ionizing Detectors

- SOP FO 16, Field Radiological Measurements

5.0 EQUIPMENT

The minimum equipment needed to handle decontamination water or wash water are the following

- Truck or trailer with enclosed sides for moving liquid waste containers
- Personal splash protection equipment
- Pump (hand or peristaltic)
- Gray drums or other liquid waste containers
- Drum handling equipment (if drums are used)

6.0 WORK AREA CHARACTERIZATIONS

Each project work area will be characterized by EG&G prior to any field activity Work area characterizations will be based on the historical background of the work area and include the chemical results of previous soil and groundwater analyses and the results of field radiological surveys conducted by EG&G RPTs or RPT designated representatives Work areas associated with the EM program field operations fall into two characterizations potentially contaminated and not potentially contaminated Work areas currently characterized as potentially contaminated include the following

- Individual Hazardous Substance Sites (IHSSs)
- Identified Groundwater Plume Areas
- Americium Zone at OU No 2
- Surface water and sediment sampling stations which have not been verified as background locations

See SOP FO 10, Receiving, Labeling, and Handling Environmental Materials Containers for specific work areas currently characterized as potentially contaminated

The types of contamination that may be encountered within potentially contaminated work areas include the following.

- Low-level radioactively contaminated substances
- Nonradioactive RCRA regulated hazardous (hazardous) substances
- Mixed (low-level radioactive and hazardous substances)

6.1 HANDLING OF DECONTAMINATION WATER AND WASH WATER

Decontamination water is soapy or clear water used for cleaning and rinsing equipment, personnel, samples, or vehicles used in work areas characterized as potentially contaminated or in not potentially contaminated work areas, where verified positive detections above background were encountered during field monitoring The water used to clean equipment used during drilling activities, regardless of the work area characterization, will be considered decontamination water

Wash water is soapy or clear water used to clean equipment, personnel, samples, or vehicles used at work areas characterized as not potentially contaminated where no verified positive readings above background were detected during field monitoring.

If a work area is characterized as not potentially contaminated but verified results from field monitoring indicate the presence of previously unsuspected contaminated substances, the water used for cleaning equipment, personnel, samples, and vehicles is considered decontamination water

6.1.1 Handling of Decontamination Water

Decontamination water will be contained by the subcontractor in gray 55-gallon drums or liquid containers The drums will be taken by the subcontractor to the main EG&G decontamination facility The decontamination facility will have an area specifically designed for environmental liquids disposal (see SOP FO.12, Decontamination Facility Operations for details pertaining to the environmental liquids area) The subcontractor will empty the entire drum's contents into this area

Other considerations to ensure the proper handling of decontamination water are

- Due to high phosphate levels, Alconox will not be used Liquinox or a phosphate-free equivalent will be used.

- Decontamination water used by subcontracting personnel must be replaced at least once daily regardless of the contamination level Replacement may be required more than once a day, depending on field conditions (i e , heavy mud or organic or radioactive contaminants)

- Use gray, 55-gallon, open top (removable top) drums or environmental liquids containers appropriately sized for the task to move decontamination water

- Liquid container lids will be secured and containers will be moved in trucks with enclosed sides

- Mark the liquid containers used for moving environmental liquids with the words "NONPOTABLE PENDING ANALYSIS" as described in SOP FO 10, Receiving, Labeling, and Handling Environmental Materials Containers

- Document the use of gray drums for moving environmental liquids on the Drum Field Log Form (Form FO 10A, see Section 8 0 - Documentation)

- Decontaminate containers used to move environmental liquids after emptying them (See SOP FO 3, General Equipment Decontamination)

- No containers with holes, leaks, or bad seals will be used for moving decontamination water

- Proper "splash" protection must be used while handling fluids (see SOP FO 4, Heavy Equipment Decontamination)

6.1.2 Handling of Wash Water

For surface water field activities in areas characterized as background stations (uncontaminated) (see SOP FO 10, Receiving, Labeling, and Handling Environmental Materials Containers), wash water and rinse water will be disposed of on the ground at least 50 feet from the sampling location such that the waste water cannot discharge into any stream, pond, or other surface water impoundment

Wash water used to clean equipment, personnel, or vehicles during surface soil sampling or groundwater sampling in work areas characterized as not potentially contaminated where no verified positive reading were detected on field monitors will be disposed of approximately 50 feet from the sampling location The disposal location must be at least 200 feet from any stream drainage

7.0 DECONTAMINATION

Decontamination of equipment used to handle and move decontamination water will be done in accordance with SOP FO 4, Heavy Equipment Decontamination and SOP FO 3, General Equipment Decontamination, and will be done between work areas so as not to promote cross-contamination of work areas Equipment and containers used for handling wash water will be power sprayed and rinsed

8 0 DOCUMENTATION

8.1 DRUM FIELD LOG FORM

If gray drums are used for moving environmental liquids, a Drum Field Log Form (Form FO 10A) will be filled out in order to maintain a "cradle to grave" record Information on the Field Drum Log Form includes

- Drum ID number
- Date of issue
- Location in field
- Contents
- Fill date
- Date of decontamination and area location
- Date returned to EG&G

Any damage incurred to a drum either during shipping or handling will be reported to an EG&G representative as soon as possible for immediate correction

Entries made on the Drum Field Log Form may be supported with entries in a field logbook

EG&G ROCKY FLATS PLANT	**Manual:**	**5-21200-OPS**
EMAD MANUAL OPERATION SOP	**Procedure No**	**FO.8, Rev 1**
	Page:	**1 of 11**
	Effective Date:	**June 10, 1991**
Category 2	**Organization**	**Environmental Management**

TITLE
HANDLING OF DRILLING FLUIDS AND CUTTINGS

Approved By

(Name of Approver) / / (Date)

1 0 TABLE OF CONTENTS

2 0 PURPOSE AND SCOPE

This standard operating procedure (SOP) will be used at the Rocky Flats Plant (RFP) to describe the proper methods to control, contain, and handle drilling fluids and cuttings

This SOP describes the handling of drill cuttings and drilling fluids and the use of organic vapor detectors (OVDs) and radiological screening for field monitoring

3.0 RESPONSIBILITIES AND QUALIFICATIONS

Personnel using light or heavy equipment, scientific monitoring devices, or operating company vehicles must have appropriate training and/or licenses

The subcontractor's site manager is responsible for the proper handling of all materials generated during drilling activities

The subcontractor is responsible for drumming drill cuttings Drums containing drill cuttings will be transferred to the custody of EG&G Waste Operations only after the drums' contents have been characterized and the drums have passed inspection Characterization will be based on analytical results of the samples corresponding to the cuttings associated with the drums' contents and the EG&G Hazardous Waste Requirements Manual (HWRM).

The subcontractor is also responsible for moving environmental liquids associated with EM drilling activities to holding tanks located at the main EG&G decontamination facility

It is the subcontractor's site manager's responsibility to report as soon as possible to the EG&G project manager or a designated EG&G representative any damage incurred to a drum Types of damage include holes, damage to the lid seal, or any other problem that may compromise drum integrity Damaged drums will have their contents transferred to an undamaged drum

The subcontractor's site manager will assign personnel to conduct weekly inspections of all the drums issued to the subcontractor until the drums are relinquished to the custody of EG&G Waste Operations These inspections will ensure that drum integrity is maintained

EG&G's Radiation Protection Technicians (RPTs) or RPT designated representatives are responsible for conducting radiation screenings of equipment, samples, and personnel before they leave potentially contaminated work areas

EG&G's Waste Operations personnel are responsible for the collection, transport, and storage, of solid environmental materials from the drum transfer area and environmental liquids from the decontamination facility

4.0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure

EG&G Hazardous Waste Requirements Manual (HWRM) June 1991

EG&G On-Site Transportation Manual 1991

EG&G Policies Rocky Flats Plant, Use and Color Coding of Drums RFPM MAT 20-005 November 3, 1989

Environmental Protection Agency (EPA) A Compendium of Superfund Field Operations Methods EPA/540/P-87/001 December 1987

Hall, Ridgway M Jr, Tom Watson, Jeffrey J Davidson, David R Case, Nancy S Bryson RCRA Hazardous Wastes Handbook 6th Edition Government Institutes, Inc. Rockville, MD March 1986

National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), U S Coast Guard (USCG), and U S Environmental Protection Agency (EPA) Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities October 1985

4.2 INTERNAL REFERENCES

Related SOPs cross-referenced in this SOP are as follows

- SOP FO.3, General Equipment Decontamination
- SOP FO 4, Heavy Equipment Decontamination
- SOP FO.5, Handling of Purge and Development Water
- SOP FO 6, Handling of Personal Protective Equipment
- SOP FO 7, Handling of Decontamination Water and Wash Water
- SOP FO 9, Handling of Residual Core and Laboratory Samples
- SOP FO 10, Receiving, Labeling, and Handling Environmental Materials Containers
- SOP FO 12, Decontamination Facility Operations
- SOP FO 15, Use of Photoionizing Detectors and Flame Ionizing Detectors
- SOP FO 16, Field Radiological Measurements
- SOP GT 2, Drilling and Sampling Using Hollow-Stem Auger Techniques

5 0 EQUIPMENT

The following items will be required during most field operations that generate drilling fluids and cuttings

- Gray, 55-gallon drums, Type 17C

- Rigid liner for drums
- Shovels and scoops with nonporous surfaces to facilitate decontamination
- Paint stick for marking drums
- Organic vapor detector (OVD)
- Field radiation monitor
- Drum bung wrench
- Tools for opening and sealing open-top 55-gallon drums with a clamp-type sealing band
- Pallets
- Opaque weather-proof sheeting
- Hand pressurized sprayer
- Desiccant
- If drilling muds are used, a seamless container (such as a molded plastic type) will be used for decanting fluids from residual sediments
- Personal Protective Equipment (PPE) as specified in the Site-Specific Health and Safety Plan
- A heavy equipment forklift or truck equipped with a drum grappler and capable of lifting a 55-gallon drum containing solid or liquid materials

6.0 CONTAMINANT CHARACTERIZATION

Each project work area will be characterized by EG&G prior to any field activity Work area characterizations will be based on the historical background of the work area and include the chemical results of previous soil and groundwater analyses and the results of field radiological surveys conducted by EG&G RPTs or RPT designated representatives Work areas associated with the EM program field operations fall into two characterizations potentially contaminated and <u>not</u> potentially contaminated Work areas currently characterized as potentially contaminated include the following

- Individual Hazardous Substance Sites (IHSSs)
- Identified Groundwater Plume Areas
- Americium Zone at OU No 2
- Surface water and sediment sampling stations that have not been verified as background locations

A listing and locator map of all known Individual Hazardous Substance Sites (IHSS) has been included in Appendix FO 10A of SOP FO 10, Receiving, Labeling, and Handling Environmental Materials Containers

Drill cuttings generated during EM field operations will be handled by containerizing them in 55-gallon gray drums as they are generated Environmental liquids generated during EM field operations will be containerized in 55-gallon, gray, closed top drums or appropriately sized containers The liquid containers will be moved to the environmental liquids area at the main decontamination facility

The use of field monitors for the detection of volatile organics and radionuclides is discussed in SOP FO 15, Use of Photoionizing Detectors and Flame Ionizing Detectors, and SOP FO 16, Field Radiological Measurements and their use is defined in the Health and Safety Plan (HSP)

The types of contamination that may be encountered within potentially contaminated work areas include the following

- Low-level radioactively contaminated substances
- Nonradioactive RCRA-regulated hazardous (hazardous) substances
- Mixed (low-level radioactive and hazardous substances)

6.1 PREDRILLING PROCEDURES

Predrilling procedures will be conducted prior to drilling a well or boring regardless of the work area characterization Predrilling procedures include the following

- Subcontracting personnel will conduct a radiological screening (see SOP FO 16, Field Radiological Measurements) of the ground surface prior to any drilling activity

- The surface soil around the staked boring or well location will be wetted with distilled water from a hand-pressurized spray bottle The wetting will be sufficient to preclude dust generation during the soil removal process

- The subcontractor personnel will use a shovel to remove a depth of approximately 20 cm of soil from an arc of sufficient size to allow for approximately 2 inches of clearance on each side of the auger. The wet soil will be spread over the ground near the drilling site Drilling activities may now begin The shovel will be decontaminated between work areas

6.2 DRILLING PROCEDURES

The auger will be positioned approximately in the center of the 20-cm-deep excavation to begin drilling As cuttings are generated, they will be wetted with distilled water from a hand-pressurized sprayer and placed on the ground

An OVD and a field radiation monitor will be used to screen core or cuttings to determine if hazardous or radioactive substances are present so that the proper PPE is selected in order to comply with the HSP In work areas requiring a radiological work permit and an Integrated Work Control Form with an appropriate work package, an EG&G RPT or RPT designated representative will be contacted to radiologically monitor the equipment and PPE at the end of each day's drilling activities The equipment and PPE will be handled per SOP FO 4, Heavy Equipment Decontamination and SOP FO 6, Handling of Personal Protective Equipment

6.3 FIELD MONITORING

OVD and field radiological screenings will be conducted by the subcontractor within each work area for all intrusive activities to ensure the safety and to determine the proper PPE to be worn by all workers The OVD and field radiological monitors will be used as described in SOP FO 15, Use of Photoionizing Detectors and Flame Ionizing Detectors, and FO 16, Field Radiological Measurements For the purposes of this SOP, the following procedures apply

- Prior to the start of work, measure the organic vapor and radioactive background level on the upwind side of the activity area Record the results on Form FO 8A, Verification of Organic Vapor Monitoring, Form FO 16A, Results of Radiological Monitoring in the Field, and in the logbook.

- Monitor the borehole for organic vapors and radiological contaminants where the intrusive work is occurring The results of monitoring shall be recorded as described in the site-specific HSP. When hollow-stem augers are being used, monitor inside the auger each time the drive head is removed When solid-stem augers are being used, monitor the cuttings at ground level each time the auger is stopped

- Single OVD or field radiological measurements greater than the background measurement may indicate the presence of hazardous or radioactive substances and must be verified as described in Subsection 6 3 1

- When an OVD or field radiological measurement above background is detected, all intrusive work will stop until the verification procedures are complete

6.3.1 Verified Positive Readings

The following verification procedures will be used after detecting an initial OVD or radiological measurement greater than the background measurement The verification process will be recorded on Form FO 8A, Verification of Organic Vapor Monitoring Results, and Form FO 16A, Results of Radiological Monitoring in the Field

- For an OVD reading above background, turn off any diesel- or gasoline-driven engines operating within the vicinity of the work area since most OVDs will detect incomplete combustion by-products

- Remove the instrument (OVD or field radiological) from the work area and make an upwind measurement of ambient organic vapor levels or radioactivity, as appropriate

- That measurement will be followed by a remeasurement at the same location where the positive measurement was recorded

- If the remeasurement is not above background, repeat the preceding actions for a third measurement and record the results

- If any two of the three measurements (including the original measurement) indicate organic vapor levels or radioactivity greater than the background level, the original measurement has been verified.

6.4 INVESTIGATIVE MATERIALS

6.4.1 Handling Drill Cuttings

Drill cuttings will be contained in gray drums with a liner (See SOP FO 10 Receiving, Labeling, and Handling Environmental Materials Containers, Section 6 3 2) regardless of the work area characterization Prior to the filling of the drum, two liters of desiccant will be placed in the bottom of the drum and two additional liters will be put into the drum when the drum has been filled half full Cuttings will be placed in the drum until the drum is full After filling, these gray drums will be sealed, locked, marked, and placed on a pallet at the drilling site After the laboratory analytical results of the environmental samples have been received and assessed by EG&G, Waste Operations will proceed with the disposition of the drums. If the drum's contents are determined to be uncontaminated, the contents will be disposed of in the landfill If the drum's contents are determined to contain hazardous substances, mixed substances, or radioactive substances, the drums will be painted the appropriate color corresponding to the characterization of the drum's contents, labeled appropriately (See SOP FO 10, Receiving, Labeling, and Handling Environmental Materials Containers), and stored by EG&G Waste Operations according to the proper SOPs contained in the HWRM and the On-Site Transporation Manual

6.4.2 Handling Drilling Fluids

If drilling fluids are to be used, the entire pumping system will be checked for leaks before the pumping system is taken to the work area Checking will consist of assembling the system and pumping potable quality water through it If a leakage in the hose connections or elsewhere is detected, it will be repaired before being used

If a drilling fluid system being used at a drill site develops a significant leak that will result in the potential contamination of the surficial soils, the system will be shut down and repaired within the work area, if feasible If repairs are not feasible within the work area, the drill rig will be removed from the work area and decontaminated before it is repaired (see SOP FO 4, Heavy Equipment Decontamination)

Drilling fluids will be contained in 55-gallon, gray, closed top drums or appropriately sized containers Field personnel should decant the environmental liquids from one drum (or container) to another (or from a trough to a drum or container) prior to moving if the amount of sediment within the environmental liquids is substantial The residual sediments will be placed in gray drums according to Section 6 4 1 of this SOP The environmental liquid containers will be moved to the environmental liquids area at the main decontamination facility (See SOP FO 12, Decontamination Facility Operations for details pertaining to the environmental liquids area) Environmental liquid containers will be marked and moved as described in SOP FO 10, Receiving, Labeling, and Handling Environmental Materials Containers The liquid containers will be emptied by the subcontractor into the decanting tanks at the decontamination facility

7.0 DOCUMENTATION

A permanent record of the implementation of this SOP will be kept by documenting field observations and data Form FO 8A, Verification of Organic Vapor Monitoring Results and Form FO 8B, Record of Drilling Fluids and Cuttings are provided to assist in the documentation of the field monitoring. Results of the field radiological monitoring will be documented in accordance with SOP FO 16, Field Radiological Measurements

Additionally, drums issued to a subcontractor by EG&G will have an associated Drum Field Log Form (FO 10A) and a Contaminant Characterization Form (FO 10C) as discussed in SOP FO 10, Receiving, Labeling, and Handling Environmental Materials Containers

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

Form FO.8B

RECORD OF DRILLING FLUIDS AND CUTTINGS

Date of Activities ______________________ Field Team Leader ______________________

1 Personnel Assigned to task that generated the wastes

Name	Assignment	Employer
______________________	Driller	______________________
______________________	Driller's Helper	______________________
______________________	Geologist	______________________
______________________	Health and Safety Tech	______________________
______________________	Other - Specify	______________________

2 Identification of site task was accomplished at ______________________________________

____

____

3 Contaminant classes assumed to be present (check as appropriate)

_______ low-level radioisotopes _______ Hazardous _______ Uncontaminated Area
_______ high-level radioisotopes _______ Mixed

4 Unanticipated contaminant classes found

_______ No _______ Yes (check as appropriate)

_______ low-level radioisotopes _______ Hazardous
_______ high-level radioisotopes _______ Mixed

5 Highest environment monitoring results

Organic vapors ____________ (value) ______ (units) ________________ (instrument used)

Radioisotopes ____________ (value) ______ (units) ________________ (instrument used)

Completed by ____
Print Name Date Signature

____
Subcontractor

(4011 REV) (FOFORM.8) (07-01 91) (3 23pm)

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT **Form FO.8A**

VERIFICATION OF ORGANIC VAPOR MONITORING RESULTS

1 Date ______________________ Work Area ______________________

2 Check Historical Contaminant Classifications

_________ Radiological _________ Hazardous _________ Mixed

3 Prework/Background Organic Vapor Monitoring Results

_________ (numeric value) _________ (units, i e ppm) _________ Instrument Used

4 Verification Measurements

Initial measurement above background ______________________

Background check ______________________

First verification measurement ______________________

Background check ______________________

Second verification measurement ______________________

5 If either of the verification measurements are above the preceding background measurement the initial measurement has been verified

Individual completing this form ______________________

Print Name Signature Date Subcontractor

HANDLING OF RESIDUAL SAMPLES

EG&G ROCKY FLATS PLANT	Manual·	5-21200-OPS
EMAD MANUAL OPERATION SOP	Procedure No..	FO 9, Rev 1
	Page·	1 of 7
	Effective Date:	June 10, 1991
Category 2	Organization:	Environmental Management

TITLE
HANDLING OF RESIDUAL SAMPLES

Approved By·

_______________________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes the waste management procedures to be implemented at the Rocky Flats Plant (RFP) for the handling of residual laboratory soil samples, and the documentation necessary to be in compliance with the RFP Waste Management Program This SOP is intended to be sufficiently detailed so that conformance will result in reliable handling of residual laboratory soil samples

3.0 RESPONSIBILITIES AND QUALIFICATIONS

3.1 SUBCONTRACTORS

The subcontractor's project manager will be responsible for assigning project staff to implement this SOP and for ensuring that the procedures are followed by all subcontractor personnel

The assigned onsite sampling manager will have a minimum of a two year college science degree and report to an assigned chemist. The sampling manager will be responsible for all coordination and required documentation as specified in this SOP between the subcontractor, EG&G, and the laboratory

Personnel using light or heavy equipment, scientific monitoring devices, or operating company vehicles must have appropriate training or licensees

3.2 LABORATORY

The laboratory will be responsible for contacting the subcontractor that originally submitted the samples prior to shipping any residual lab soil samples The laboratory will also be required to provide all documentation, as specified in this SOP, to the subcontractor and ship all laboratory residual soil samples in accordance with all applicable Department of Transportation (DOT) regulations

3.3 EG&G

The EG&G project manager has the overall responsibility for implementing this SOP EG&G will be responsible for approving all Residual Lab Soil Characterization (RLSC) forms and final disposition of all residual laboratory soils

4.0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure

A Compendium of Superfund Field Operations Methods EPA/540/P-87/001 December 1987

RCRA Facility Investigation Guidance. Interim Final May 1989

4.2 INTERNAL REFERENCES

Related SOPs cross-referenced in this SOP are as follows

- SOP FO 10, Receiving, Labeling, and Handling Waste Containers
- SOP FO 12, Decontamination Facility Operations

5.0 PROCEDURE FOR THE HANDLING OF RESIDUAL SAMPLES

Residual laboratory soil samples consist of excess soils collected at RFP that were not used by the chemical laboratory for analyses and are being returned to RFP

The following procedures are guidelines to be followed by the subcontractor for the proper chemical characterization, movement, storage, and containment of residual laboratory soils being returned to RFP by EG&G's contracted chemical laboratories

5.1 RECEIVING RESIDUAL LABORATORY SAMPLES

Chemical laboratories requesting to return residual soil samples will first contact the subcontractor that originally submitted the soil samples to the laboratory The subcontractor will require all documentation specified in this SOP The laboratory will provide the subcontractor with the following notification of shipment

- Sample identification list of residual soils to be returned to RFP
- Method of shipment (i e , courier)
- Expected date and time of delivery
- Number of shipping containers
- Total number of individual sample containers

5.2 CHARACTERIZING RESIDUAL LABORATORY SAMPLES

Once the subcontractor receives all required information from the laboratory, the subcontractor will access the Rocky Flats Data Management System (RFDMS) for the validated chemical results of the associated soil sample The subcontractor will categorize each soil as radioactive, hazardous (nonradioactive RCRA-regulated hazardous substances), or non-hazardous based upon the chemical results The chemical categorization will be performed by the subcontractor's assigned sample manager and chemist All chemical categorizations performed by subcontracting personnel will be based on validated chemical results of the associated soil sample obtained during field sampling activities

Following the subcontractor's chemical categorization of each residual soil sample to be returned to EG&G, the subcontractor will complete a Residual Lab Soil Characterization (RLSC) Form (Form FO 9A) This form will identify the name of the subcontractor, the chemical laboratory requesting the return shipment, the date of request, and the RLSC identification (I D) number (sample I D) Included on this form will be the subcontractor's chemical categorization of each soil sample which will be identified as follows

- Uncontaminated
- Low-level radioactivity contaminated (RAD)
- Nonradioactive RCRA-regulated hazardous (hazardous)
- Mixed (RAD and hazardous)

The subcontractor will also cross-reference the original Chain-of-Custody (COC) number to the residual soil sample and record that COC number on the spaces provided on the RLSC Form.

The RLSC form(s) and associated chemical results will be submitted to EG&G for final characterization and approval of acceptance of the residual laboratory soil samples Following EG&G's waste characterization and approval, the RLSC Form and associated chemical analyses will be returned to the subcontractor The subcontractor will authorize the chemical laboratory to proceed with the return shipment of the designated residual laboratory soils to RFP

5.3 RECEIVING SAMPLE SHIPMENTS

The laboratory will address the residual laboratory soils to the subcontractor at RFP The samples will be shipped in accordance with all applicable DOT shipping regulations The laboratory will also provide duplicate copies of the associated COC form(s) pertaining the residual laboratory soils The duplicate copies of the COC forms are to be securely placed on the outside of the shipping container(s) and well protected from the weather

When the designated residual soil samples are received by EG&G's Shipping and Receiving Department, the subcontractor will be notified of the shipment The subcontractor will move the unopened sample container(s) (coolers or packages) to the main decontamination facility At the main decontamination facility, the subcontractor will open the sample cooler(s) in accordance with the Environmental Management's Project Health and Safety Plan The subcontractor will inspect the contents in each sample container, assess damage, and ensure that all individual sample containers are listed on the accompanied COC form

Samples identified on the COC by the subcontractor that cannot be accounted for will be lined-out, dated, and initialed on both COC copies This discrepancy will be documented on the COC forms and the laboratory will be notified

If containers are inventoried by the subcontractor during inspection and are not listed on the COC forms, the subcontractor will separate the non-listed sample container(s) and contact the laboratory and EG&G for further guidance

If a sample container is found to be broken, the sample manager will check the EG&G characterization of the contents of the container If the contents are characterized as uncontaminated, the sample will be left in the shipment container If the soils within the broken sample container are characterized as RAD, hazardous, or mixed, the sample manager will contact the EG&G project manager for further guidance

If the sample containers are undamaged, the subcontractor will segregate each sample container based on the EG&G characterization of the sample Sample containers having the same characterization will be repackaged together Each new package will be labeled according to the characterization of samples Packages containing samples characterized as RAD will be labeled with a "White I" radioactive label Packages containing samples characterized as hazardous or mixed will be labeled with a Department of Transportation (DOT) "Other Regulated Materials Class E" (ORM-E) sticker Additionally, packages containing mixed residual samples will be marked with the word "RAD " (See SOP FO 10, Receiving, Labeling, and Handling Waste Containers for details pertaining to the proper handling of waste containers)

The subcontractor will then place the repackaged samples at the drum transfer area at the main decontamination facility (see SOP FO 12, Decontamination Facility Operations) The subcontractor will have EG&G's Waste Operations personnel sign both copies of the COC forms Custody of the residual soil samples is now considered officially transferred to EG&G

The subcontractor will relinquish one copy of the COC form(s) to EG&G's Waste Operations personnel The subcontractor will retain the duplicate COC form(s) to complete the subcontractor's document package that will ensure that residual soils were appropriately handled and returned to RFP.

5.4 DOCUMENT PACKAGE

The subcontractors's document package for residual laboratory samples returned to EG&G's custody will contain the following information for each shipment·

- An EG&G signed copy of the COC form(s)
- A copy of the completed RLSC form(s) and associated chemical analyses
- Laboratory notification of shipment

These document packages are to be filed in the subcontractor's project QA files and kept until requested by EG&G for permanent storage

6.0 DOCUMENTATION

Information requested by this SOP will be documented on the RLSC (Form FO 9A) form(s) and the COC(s)

RESIDUAL LAB SOIL CHARACTERIZATION FORM (RLSC)

ATTACH CHEMICAL RESULTS OF ASSOCIATED SAMPLES

THIS PORTION WILL BE COMPLETED BY THE SUBCONTRACTOR AND APPROVED BY EG&G

Name of Subcontractor ______________________

Name of Chemical Laboratory ______________________

Date of Request ______________________

Are Associated Chemical Results Attached? (Y/N) ______________________

Subcontractor's Signature ______________________
Date ______________________
Comments ____

____

EG&G Project Manager ______________________
Residual Lab Soil Characterization

Sample I.D	Original COC #	Characterization

Comments ____

____

EG&G Approval Signature ______________________
Date ______________________

EG&G ROCKY FLATS PLANT	Manual:	5-21200-OPS
EMAD MANUAL OPERATION SOP	Procedure No	FO.10, Rev 1
	Page	1 of 19
	Effective Date	June 10, 1991
Category 2	Organization	Environmental Management

TITLE
RECEIVING, LABELING, AND HANDLING ENVIRONMENTAL MATERIALS CONTAINERS

Approved By

______________________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIXES

2.0 PURPOSE AND SCOPE

The environmental materials generated from Environmental Management (EM) field activities will be handled in accordance with the Rocky Flats Plant (RFP) waste management program This standard operating procedure (SOP) describes procedures that will be used by subcontractors at RFP to receive, mark, and handle environmental drums until they are returned to RFP's representative, EG&G

These procedures are intended to be sufficiently detailed so that conformance with them will result in reliable drum handling and management

3.0 RESPONSIBILITIES AND QUALIFICATIONS

Personnel using light or heavy equipment, scientific monitoring devices, or operating company vehicles must have appropriate training and/or licenses

The subcontractor's site manager is responsible for the proper handling of all materials generated during drilling activities

The subcontractor is responsible for drumming drill cuttings and other solid materials associated with environmental activities The transfer of drums to the custody of EG&G Waste Operations personnel shall occur once the drum's contents have been characterized, the drum has been inspected, and space is available at the Waste Operations transfer/storage area

The subcontractor is also responsible for moving environmental liquids associated with EM drilling activities to holding tanks located at the main EG&G decontamination facility

It is the subcontractor's site manager's responsibility to report as soon as possible to the EG&G project manager or a designated EG&G representative any damage incurred to a drum Types of damage include holes, damage to the lid seal, or any other problem that may compromise drum integrity Damaged drums will have their contents transferred to an undamaged drum

The subcontractor's site manager will assign personnel to conduct monthly inspections of the drums issued to the subcontractor until relinquished to the custody of EG&G These inspections will ensure that drum integrity is maintained

EG&G's Radiation Protection Technicians (RPTs) or RPT designated representatives are responsible for conducting radiation screenings of equipment, samples, and personnel before they leave potentially contaminated work areas

EG&G's Waste Operations personnel are responsible for the collection, transport, storage, treatment, and disposal of solid and liquid environmental materials from the drum transfer area at the main decontamination facility

4.0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure

EG&G Hazardous Waste Requirements Manual (HWRM) June 1991

EG&G On-site Transportation Manual 1991

EG&G Policies Rocky Flats Plant, Use and Color Coding of Drums RFPM MAT 20-005 November 3, 1989

Environmental Protection Agency (EPA) A Compendium of Superfund Field Operations Methods EPA/540/P-87/001 December 1987

Hall, Ridgway M Jr , Tom Watson, Jeffrey J Davidson, David R Case, Nancy S Bryson RCRA Hazardous Wastes Handbook 6th Edition Government Institutes, Inc Rockville, MD March 1986

National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), U S Coast Guard (USCG), and U S Environmental Protection Agency (EPA) Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities October 1985

4.2 INTERNAL REFERENCES

Related SOPs cross-referenced in this SOP are as follows

- SOP FO 3, General Equipment Decontamination
- SOP FO 5, Handling of Purge and Development Water
- SOP FO 6, Handling of Personal Protective Equipment
- SOP FO 7, Handling of Decontamination Water and Wash Water
- SOP FO 8, Handling of Drilling Fluids and Cuttings
- SOP FO 9, Handling of Residual Samples
- SOP FO 12, Decontamination Facility Operations
- SOP FO 15, Use of PIDs and FIDs
- SOP FO 16, Field Radiological Measurements

5.0 EQUIPMENT

Several types of equipment can be used to move drums too heavy to lift safely A list of appropriate equipment includes

- A drum grappler attached to a hydraulic excavator

- A small front-end loader, which can be either loaded manually or equipped with a bucket sling

- A rough terrain forklift

- A roller conveyor equipped with solid rollers

- Drum carts designed specifically for drum handling

- Miscellaneous sizes of wrenches, sockets, and socket ratchets for opening and sealing drums

- Wood pallets

- Plastic or nylon banding

The drum grappler is the preferred equipment for handling heavy drums (NIOSH, et al , 1985)

6.0 WORK AREA CHARACTERIZATIONS

Each project work area will be characterized by EG&G prior to any field activity Work area characterizations will be based on the historical background of the work area and include the chemical results of previous soil and groundwater analyses and the results of field radiological surveys conducted by EG&G RPTs or RPT designated representatives Work areas associated with the EM program field operations fall into two characterizations potentially contaminated and <u>not</u> potentially contaminated Work areas currently characterized as potentially contaminated include the following

- Individual Hazardous Substance Sites (IHSSs)
- Identified Groundwater Plume Areas

- Americium Zone at OU No 2
- Surface water and sediment sampling stations that have not been verified as background locations

Potentially contaminated work areas where groundwater plumes have been identified will be specified in the applicable work plans, as appropriate Table FO 10-A1 of Appendix FO 10A lists the IHSS work areas at RFP Figure FO 10-A1, of Appendix A, shows the locations of the RFP IHSSs Figure FO 10-1 illustrates the identified groundwater plume areas and the americium area at OU No 2 Table FO 10-1 lists the surface water and sediment stations (locations) that have been verified as background stations (uncontaminated) as of December, 1990 Other surface and sediment sampling stations will be added to this list as they become verified as background stations Unless specified in the individual project work plans, all other work areas will be considered potentially contaminated

Various types of environmental materials are generated during EM field operations Solid environmental materials for the purpose of EM waste management at the RFP include drill cuttings, sludge, surface soils, and disposable personal protective equipment (PPE) Environmental liquids generated during field activities include drilling fluids, decontamination and wash water, and residual groundwater and surface water samples

The types of contamination that may be encountered within potentially contaminated work areas include the following

- Low-level radioactively contaminated substances
- Nonradioactive RCRA-regulated hazardous (hazardous) substances
- Mixed (low-level radioactive and hazardous substances)

The use of field monitors for the detection of volatile organics and radionuclides is discussed in SOPs FO 8, Handling of Drilling Fluids and Cuttings, FO 15, Use of Photoionizing Detectors and Flame Ionizing Detectors, and FO 16, Field Radiological Measurements

TABLE FO 10-1

BACKGROUND SURFACE WATER AND SEDIMENT STATIONS

FOR

ROCKY FLATS PLANT

Surface Water Station Number	Sediment Station Number	Location
SW004	SED 22	Rock Creek Drainage
SW005	SED 20	Rock Creek Drainage
SW006	SED 23	Rock Creek Drainage
SW108	SED 21	Rock Creek Valley Wall
SW007	SED 04	Tributary of Walnut Creek
SW041	SED 17	Tributary of Woman Creek
SW080	SED 18	Tributary of Woman Creek (spring)
SW104	SED 19	Tributary of Woman Creek (spring)
SW107	SED 16	Woman Creek Drainage
SW042	SED 15	Offsite Gravel Pits

Draft Background Geochemical Characterization Report
Rocky Flats Plant Golden Colorado
rockwell\bkgdchem\sed 3a jbb

Environmental materials generated within work areas characterized as not potentially contaminated and where no verified positive readings were detected on field monitors will be considered uncontaminated and handled as described in following SOPs

- SOP FO 5, Handling of Purge and Development Water
- SOP FO.6, Handling of Personal Protective Equipment
- SOP FO 7, Handling of Decontamination Water and Wash Water
- SOP FO 8, Handling of Drilling Fluids and Cuttings
- SOP FO 9, Handling of Residual Samples

7.0 DRUM RECEIVING, LABELING, AND HANDLING PROCEDURES

7.1 RECEIVING

Environmental drums can be obtained by contacting the EG&G project manager The amount and type of drums required to perform the work should be specified by the subcontractor The EG&G project manager will direct the subcontractor to the appropriate drum distribution area An advance notice of two days is preferred

7.1.1 Drum Color Codes

EG&G has segregated drums into a color coding scheme for identification to ensure the proper management of waste (RFPM MAT 20-005) The color code identifies the suspected contaminant characterization of the materials within the drums The color scheme has been modified to specifically address EM operations EM drums are gray and contain only environmental materials pending analysis and characterization The types of EM drums are as follows

- Gray Drums 1 Gray, 55-gallon, open top (removable top) drums will be used for the temporary containment of uncharacterized drill cuttings and PPE These environmental materials are awaiting the results of chemical analyses for contaminant characterization

2 Gray, 55-gallon, closed top drums will be used for moving environmental liquids to the main EG&G decontamination facility and emptied

Other closable transfer containers, appropriately sized for the volume of water generated by the tasked activity, may also be used for moving environmental liquids associated with drilling activities to the holding tanks at the central decontamination facility

Uncontaminated disposable PPE and uncontaminated miscellaneous solid environmental materials will be placed in garbage cans lined with plastic bags at the work area When full, these plastic bags will be transferred to EG&G's custody at a designated transfer area

7.2 MARKING

The subcontractor will give a sequential number for each gray drum received A two-letter subcontractor ID will follow directly behind the drum ID number The letter ID will be chosen by the subcontractor For example, "1326WC" would identify Drum Number 1326 handled by Woodward-Clyde Additionally, an identifying marking will be associated with each drum A Drum Field Log Form (Form FO 10A, see Section 7 0-Documentation) will be used by the subcontractor to track each drum used for containing solid environmental materials until returned to EG&G

7.2.1 Environmental Liquids

Environmental liquids generated within the following work areas will be characterized as potentially contaminated

- Surface water and sediment sampling stations which have not been verified as background locations

- Work areas where drilling activities are being conducted

These environmental liquids will be placed in gray drums or appropriately sized liquid transfer containers and moved by the subcontractor's personnel Field personnel should decant the environmental liquids from one drum (or container) to another (or from a trough to a drum or transfer container) if the amount of sludge and sediment within the environmental liquids is substantial The residual sediment will be contained in gray drums as described in Subsection 6 3 2 The environmental liquids will then be brought to the central EG&G decontamination facility The decontamination facility will have an area specifically designed to receive environmental liquids The environmental liquids area will include a decanting process to remove residual sludges and sediments remaining within the liquid The subcontractor will empty the entire drum's contents into this area The environmental liquids will be pumped from the decanting area to holding tanks When a liquid holding tank is full, an EG&G designated subcontractor will take a representative sample from the tank for volatile organic analysis (see SOP FO 12, Decontamination Facility Operations) Environmental liquids must be transported to the 374 evaporator or the granulated activated carbon (GAC) unit within 90 days

The following marking and handling procedures apply to any containers used for moving environmental liquids

- In addition to the ID number, the drums or liquid containers will be marked with the words "NONPOTABLE PENDING ANALYSIS "

- A paint stick (or indelible marker) should be used to apply identifying marks on liquid transfer containers to ensure that the markings will not be washed away during decontamination or precipitation Paint should not be applied in the vicinity of sampling or field monitoring events to prevent cross-contamination of samples

- Identifying marks should be legible, approximately 5 inches high, and written on two (opposite) sides and on the top of the container

- An EG&G RPT or RPT designated representative will do a radiation screening test on the exterior of the container before the container leaves the work area If necessary, the exterior of the container will be decontaminated

- Environmental liquids container lids will be secured before the containers are moved Containers will be moved in trucks with enclosed sides and will not be stacked

- After the container's contents have been emptied, the subcontractor's personnel will decontaminate the container prior to any additional use (see SOP FO 3, General Equipment Decontamination)

- Empty gray drums may be stored by the subcontractor at a designated location in the work area Drums will be banded to prevent them from blowing away

- The subcontractor will designate personnel to inspect the integrity of the drums on a weekly basis Drums will be inspected for damage according to the Hazardous Waste Requirements Manual (HWRM) Types of damage include holes, damage to the lid seal, or any other problem that may compromise drum integrity The subcontractor will report as soon as possible to the EG&G project manager or a designated EG&G representative any damage incurred to a drum Damaged drums must have their contents transferred to an undamaged drum The results of this inspection will be documented on a

Drum Inspection Form (Form FO 10B, see Section 7 0-Documentation), dated, and signed by the person performing the inspection

- Any containers used off site, such as decontamination and wash water containers, must meet DOT specifications for containers, markings, and labeling (see Subsection 6 3 2)

For surface water field activities in areas characterized as background stations (uncontaminated), wash water and rinse water will be disposed of on the ground at least 50 feet from the sampling location such that the waste water cannot discharge into any stream, pond, or other surface water impoundment

Wash water used to clean equipment, personnel, or vehicles during surface soil sampling or groundwater sampling in work areas characterized as not potentially contaminated where no verified positive readings were detected on field monitors will be disposed of approximately 50 feet from the sampling location The disposal location must be at least 200 feet from any stream drainage

7.2.2 Temporary Containment of Solid Environmental Materials Pending Characterization

Gray drums will be used for the temporary containment of solid environmental materials that are pending characterization including drill cuttings and PPE For drums that will contain drill cuttings, a liner will be placed in the drum and two liters of desiccant will be placed in the bottom of the drum Two additional liters will be put into the drum when the drum has been filled half full Cuttings will be placed in the drum until the drum is full After filling, gray drums will be sealed, marked, and placed on pallets Representative environmental samples from an associated well, boring, or sampling location will be sent to an off site laboratory for a full suite of analytical results to characterize these environmental materials The drums will remain at the drilling site until a Waste Operations storage area is available

At the time Waste Operations notifies EM that space is available, the drums will be moved to the transfer/storage area to await assessment of the associated environmental samples

The subcontractor will perform the following steps to ensure the proper handling of the gray drums until transferred to EG&G custody

- In addition to the drum number, the drums will be marked with the words "ENVIRONMENTAL MATERIAL PENDING ASSESSMENT", the associated well, boring, or sampling number and location, the word "SOIL", or "PPE" (for disposable personnel protective equipment), as appropriate, the subsurface interval (if soil), and the date the drum was filled (Soils will not be commingled with miscellaneous environmental materials or PPE within a drum)

- A paint stick (or indelible marker) should be used to apply identifying marks on drums to ensure that the marks will not be washed away during decontamination or precipitation A paint stick should not be applied in the vicinity of sampling or field monitoring events to prevent cross-contamination of samples

- Identifying marks should be legible, with characters approximately 5 inches high, and written on two (opposite) sides and on the top of the drum

- Gray drums will be placed on wood pallets at the drilling site

- The appropriate information will be documented on the Drum Field Log Form (Form FO 10A)

- Gray drums will be transferred to EG&G's custody at a designated pickup/transfer area only after the drum's contents have been characterized

The drums should be placed on wood pallets at the pickup/transfer area to assist the transfer

- An EG&G RPT or RPT designated representative will do a radiation screening test on the exterior of the drum before the drum leaves the work area If necessary, the exterior of the drum will be decontaminated

- Drum lids will be secured and drums will be moved in trucks with enclosed sides

- A copy of the completed Drum Field Log Form (Form FO 10A) will be given to the receiving EG&G Waste Operations personnel (see Section 7 0 - Documentation)

- Drums will be decontaminated prior to any reuse, and the old markings should be spray-painted over and/or a new marking applied

- A drum number should never be painted over or changed

When the validated chemical analyses from the environmental samples are received by EG&G, Waste Operations will be sent a summary of the results from the EG&G project manager If the drum's contents are determined to be uncontaminated, the contents will be disposed of in the landfill

If the drums are determined to contain hazardous substances, mixed substances, or radioactive substances, the gray drums will be painted the appropriate color corresponding to the characterization of the drum's contents and labeled appropriately (See Section 7 3, Labeling, below) by EG&G Waste Operations

Field monitoring including OVDs and radiation detectors will be used during intrusive activities regardless of the work area classification SOP FO 8, Handling of Drilling Fluids and Cuttings describes the use of field monitors for intrusive activities as well as verifying positive readings

7.3 LABELING

Gray drums containing solid environmental materials that have been characterized as radioactive or mixed will be painted white If the drum's contents have been characterized as radioactive but not hazardous, the drum will be labeled with a "White I" radioactive label If the drum's contents have been characterized as mixed, the drum will be labeled with an ORM-E label per HWRM and the On-site Transportation Manual requirements

Gray drums containing solid environmental materials that have been characterized as hazardous only will be painted white on the ends and black in the center These drums will be labeled with an ORM-E sticker per HWRM and the On-site Transportation Manual requirements

8.0 DOCUMENTATION

A permanent record of the implementation of this SOP will be kept by documenting field observations and data Observations and data will be recorded on drum field log forms Subcontracting personnel may also choose to document the observations and data in a personal field notebook in addition to the field log forms If a field book is used, entries should be made with a black waterproof ink pen The field notebook should be waterproofed and have consecutively numbered pages

It is recommended that the subcontractor bring duplicate copies of the completed Drum Field Log Form when transferring custody of waste drums to EG&G personnel Both copies should be signed by the receiving EG&G representative EG&G Waste Operations will retain one signed copy and the subcontractor will retain the second signed copy in the project files

Drum forms will be kept in the subcontractor's project files until the project is completed All project files will be turned over to EG&G at this time (see SOP FO 2, Field Documentation)

8.1 DRUM FIELD LOG FORMS

A Drum Field Log Form will be kept on each drum by the subcontractor from the time of issuance until returned to an EG&G representative At a minimum, the forms will include the following

- The name of the subcontractor issued the drum
- The color of the drum
- The identification number with the subcontractor's ID
- The date the drum was issued
- The location of the field activity area
- The contents of the drum (include the subsurface interval if contents are soils from a well or boring)
- The date the drum was filled
- The date the drum was decontaminated or returned to EG&G (include the EG&G facility where the drum was returned to)

Form FO 10A is an example of the Drum Field Log Form to be used Drum log forms must be checked and updated immediately upon handling In addition to the drum marking, the Drum Field Log Form will identify the drum and provide a history of the drum All the field log forms combined will be used to track the movement of environmental materials generated during EM field operations

8 2 DRUM INSPECTION FORM

The subcontractor is responsible for conducting monthly inspections of all the gray drums they have been issued until the drum is returned to EG&G Monthly inspections will ensure that the integrity of the drums is maintained The Drum Inspection Form (Form FO 10B) will be used to document these inspections

8.3 CONTAMINANT CHARACTERIZATION FORM

The Contaminant Characterization Form (Form FO 10C) will be used for the characterization of materials that have been temporarily stored in gray drums until analytical results are received Upon receipt of all the sample methods for each sample associated with the drum, the subcontractor will submit the drum identification portion of the form along with the analytical results to the EG&G project manager The drum contents will be characterized by an EG&G representative based on the chemical analyses and returned to EG&G's Waste Operations personnel

8.4 COMPUTER LOG FORMS

All information found on drum field log forms may be entered into a computer database by designated subcontractor personnel This will allow the immediate tracking of any environmental drum used by a subcontractor during EM field activities and will provide a backup to the field log forms

DEPARTMENT OF ENERGY ROCKY FLATS PLANT

DRUM FIELD LOG FORM

FORM FO.10A

NAME OF THE SUBCONTRACTOR ______________________

DRUM ID NUMBER WITH SUBCONTRACTOR'S ID ______________________

LOCATION AND DATE OF ISSUANCE ... LOC ______________ DATE ______________

NAME AND LOCATION OF FIELD ACTIVITY ... NAME ______________ LOC ______________

ASSOCIATED WELL, BORING, OR SAMPLING LOCATION ... NAME ______________

CONTENTS OF DRUM ______________________

SUBSURFACE INTERVALS (IF SOILS)

BAG #S (IF PPE) ______________________

ASSOCIATED SAMPLE ID #S ______________________

DATE DRUM WAS FILLED ______________________

SIGNATURE OF PERSON FILLING THE DRUM ______________________

IF SOLID ENVIRONMENTAL MATERIALS

LOCATION OF TEMPORARY STORAGE AREA ______________________

DATE DRUM RETURNED TO EG&G ______________________

SIGNATURE OF EG&G REPRESENTATIVE ______________________

IF ENVIRONMENTAL LIQUIDS

DATE AND LOCATION WHERE CONTENTS WERE EMPTIED AND DECONNED ... DATE ______________ LOC ______________

(EXAMPLE 2/18/91 DECON PAD #____)

FORM FO 10B

DRUM INSPECTION FORM

DRUM ID NUMBER/SUB ID ____________________

INSPECTION DATE	STATUS	INSPECTOR'S SIGNATURE

(4011 REV)(FORMFO10AB WK1)(6/7/91)

U S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT FORM FO 10C

CONTAMINANT CHARACTERIZATION FORM FOR GRAY DRUMS PENDING CHARACTERIZATION

ATTACH CHEMICAL RESULTS OF ASSOCIATED SAMPLES

THIS PORTION WILL BE COMPLETED BY SUBCONTRACTOR

Name of the Subcontractor Issued the Drum ______

The serialized Drum ID number with the Subcontractor's ID ______

The Date the Drum Was Taken to a Field Activity ______

The Location of the Field Activity Area ______

The Contents of the Drum ______

(Subsurface Intervals, if Soils) ______

(Bag #s, if PPE) ______

______

______

______

______

The Date the Drum was Filled ______

The Associated Well, Boring, or Sample location ______

Matrix of Sample Analyzed ______

Sample ID #s ______

______

______

______

______

Intervals Sample was Taken From ______

______

______

______

______

Date Submitted to EG&G for Characterization ______

Subcontractor's Representative Signature ______

THIS PORTION WILL BE COMPLETED BY EG&G

The Contaminant Characterization of the Drum's Contents ______

Signature of EG&G Representative Determining the Contaminant Characterization and Date Signed ______

Date ______

EG&G Holding Facility Where Drum Will be Stored ______

Date and Time Form Returned to Waste Operations Date______ Time______

(4011-REV)(FO10REV 1)(07/02/91)

APPENDIX A

APPENDIX A

TABLE A1
ROCKY FLATS PLANT
INDIVIDUAL HAZARDOUS SUBSTANCE SITES

REF NO	SITE NAME
101	207 SOLAR EVAPORATION PONDS
102	OIL SLUDGE PIT
103	CHEMICAL BURIAL
104	LIQUID DUMPING
105	OUT-OF-SERVICE FUEL TANKS
	105 1 - WESTERNMOST TANK
	105 2 - EASTERNMOST TANK
106	OUTFALL
107	HILLSIDE OIL LEAK
108	TRENCH T-1
109	TRENCH T-2
110	TRENCH T-3
	TRENCHES T-4 TO T-11
	111 1 TRENCH T-4
	111 2· TRENCH T-5
	111 3 TRENCH T-6
	111 4 TRENCH T-7
	111 5 TRENCH T-8
	111 6 TRENCH T-9
	111 7 TRENCH T-10
	111 8 TRENCH T-11
112	903 DRUM STORAGE AREA
113	MOUND AREA
114	PRESENT LANDFILL
115	ORIGINAL LANDFILL
116	MULTIPLE SOLVENT SPILLS
	116 1 WEST LOADING DOCK AREA
	116 2 SOUTH LOADING DOCK AREA

Note This information is based on the administrative record including the information submitted in the hazardous and low-level mixed waste Part B application dated November 1, 1985, as modified by the subsequent revision dated November 28, 1986, as modified by the subsequent revision dated December 15, 1987, and the transuranic mixed waste Part B application submitted July 1, 1988, Thereafter referred to as the applications This information is also based on independent review of historical aerial photographs of the facility and independent review of facility submittals

TABLE A1 (cont)

INDIVIDUAL HAZARDOUS SUBSTANCE SITES

REF NO	SITE NAME
117	CHEMICAL STORAGE
	117 1 NORTH SITE
	117 2 MIDDLE SITE
	117 3 SOUTH SITE
118	MULTIPLE SOLVENT SPILLS
	118 1 WEST OF BUILDING 731
	118 2 SOUTH END OF BUILDING 776
119	MULTIPLE SOLVENT SPILLS
	119 1 WEST AREA
	119 2 EAST AREA
120	FIBERGLASSING AREAS
	120 1 NORTH OF BUILDING 664
	120 2 WEST OF BUILDING 664
121	ORIGINAL PROCESS WASTE LINES
122	UNDERGROUND CONCRETE TANK
123	VALVE VAULT 7
	123 1 VALVE VAULT 7
	4,000 GALLON TANK #67)
125	HOLDING TANK
126	OUT-OF-SERVICE PROCESS WASTE TANKS
	126 1 WESTERNMOST TANK
	126 2 EASTERNMOST TANK
127	LOW-LEVEL RADIOACTIVE WASTE LEAK
128	OIL BURN PIT NO. 1
129	OIL LEAK
130	RADIOACTIVE SITE - 800 AREA SITE #1
131	RADIOACTIVE SITE - 700 AREA SITE $1
132	RADIOACTIVE SITE - 700 AREA SITE #4
133	ASH PITS
	133 1 ASH PIT 1-1
	133 2 ASH PIT 1-2
	133 3 ASH PIT 1-3
	133 4 ASH PIT 1-4
	133 5 INCINERATOR
	133 6 CONCRETE WASH PAD
134	LITHIUM METAL DESTRUCTION SITE
135	COOLING TOWER BLOWDOWN

TABLE A1 (cont)
INDIVIDUAL HAZARDOUS SUBSTANCE SITES

REF. NO	SITE NAME
136	COOLING TOWER PONDS
	136 1 NORTHEAST CORNER OF BUILDING 460
	136 2 WEST OF BUILDING 460
	136 3 S OF BLDG 460, W OF BLDG 444
137	COOLING TOWER BLOWDOWN - BLDG 774
138	COOLING TOWER BLOWDOWN - BLDG 779
139	CAUSTIC/ACID SPILLS
	139 1. HYDROXIDE TANK AREA
	139 2 HYDROFLUORIC ACID TANKS
140	REACTIVE METAL DESTRUCTION SITE
141	SLUDGE DISPERSAL
142	RETENTION PONDS (A,B,C-SERIES)
	142 1 A-1 POND
	METAL DESTRUCTION SITE
141	SLUDGE DISPERSAL
142	RETENTION PONDS (A,B,C-SERIES)
	142.1 A-1 POND
	142 2 A-2 POND
	142 3· A-3 POND
	142 4. A-4 POND
	142 5 B-1 POND
	142 6 B-2 POND
	142.7 B-3 POND
	142 8 B-4 POND
	142 9 B-5 POND
	142 10 C-1 POND
	142 11 C-2 POND
	142 12 NEWLY IDENTIFIED A-5 POND
143	OLD OUTFALL
144	SEWER LINE BREAK
145	SANITARY WASTE LINE LEAK
146	CONCRETE PROCESS WASTE TANKS
	146 1 7,500 GALLON TANK (#31)
	146 2 7,500 GALLON TANK (432)
	146 3 7,500 GALLON TANK (*34W)
	146 4 7,500 GALLON TANK (#34E)
	146 5 3,750 GALLON TANK (*30)
	146 6 3,750 GALLON TANK (#33)
147	PROCESS WASTE LEAKS
	147 1 MAAS AREA
	147 2 OWEN AREA
148	WASTE SPILLS
149	EFFLUENT PIPE

INDIVIDUAL HAZARDOUS SUBSTANCE SITES

REF. NO	SITE NAME
150	RADIOACTIVE LIQUID LEAKS (8)
	150 1 NORTH OF BUILDING 771
	150 2 WEST OF BUILDING 771
	150 3 BETWEEN BUILDINGS 771 ant 774
	150 4 EAST OF BUILDING 750
	150 5 WEST OF BUILDING 707
	150 6 SOUTH OF BUILDING 779
	150 7 SOUTH OF BUILDING 776
	150 8 NORTHEAST OF BUILDING 770
151	FUEL OIL LEAK
152	FUEL OIL TANK
153	OIL BURN PIT NO 2
154	PALLET BURN SITE
155	903 LIP AREA
156	RADIOACTIVE SOIL BURIAL
	156 1· BUILDING 334 PARKING LOT
	156 2 SOIL DUMP AREA
157	RADIOACTIVE SITE
	157 1 NORTH AREA
	157 2 SOUTH AREA
158	RADIOACTIVE SITE - BLDG 551
159	RADIOACTIVE SITE - BLDG 559
160	RADIOACTIVE SITE - BLDG 444 PK LOT
161	RADIOACTIVE SITE - BLDG 664
162	RADIOACTIVE SITE - 700 AREA SITE #2
163	RADIOACTIVE SITE - 700 AREA SITE #3
	163 1 WASH AREA
	163 2 BURIED SLAB
164	RADIOACTIVE SITE - 800 AREA SITE #2
	164 1 CONCRETE SLAB
	164 2 BUILDING 886 SPILLS
	164 3 BUILDING 889 STORAGE PAD
165	TRIANGLE AREA
166	TRENCHES
	166 1 TRENCH A
	166 2 TRENCH B
	166 3 TRENCH C
167	SPRAY FIELDS - THREE SITES
	167 1 NORTH AREA
	167 2 POND AREA
	167 3 SOUTH AREA
168	WEST SPRAY FIELD

TABLE A1 (cont)
INDIVIDUAL HAZARDOUS SUBSTANCE SITES

REF NO	SITE NAME
169	WASTE DRUM PEROXIDE BURIAL
170	P U & D STORAGE YARD - WASTE SPILLS
171	SOLVENT BURNING GROUND
172	CENTRAL AVENUE WASTE SPILL
173	RADIOACTIVE SITE - 900 AREA
174	P U &D CONTAINER STORAGE FACILITIES (2)
175	S&W BLDG 980 CONTAINER STORAGE FACILITY
176	S&W CONTRACTOR STORAGE YARD
177	BUILDING 885 DRUM STORAGE AREA
178	BUILDING 881 DRUM STORAGE AREA
179	BUILDING 865 DRUM STORAGE AREA
180	BUILDING 883 DRUM STORAGE AREA
181	BUILDING 334 CARGO CONTAINER AREA
182	BUILDING 444/453 DRUM STORAGE AREA
183	GAS DETOXIFICATION AREA
184	BUILDING 991 STEAM CLEANING AREA
185	SOLVENT SPILL
186	VALVE VAULT 12
187	ACID LEAKS (2)
188	ACID LEAK
189	MULTIPLE ACID SPILLS
190	CAUSTIC LEAK
191	HYDROGEN PEROXIDE SPILL
192	ANTIFREEZE DISCHARGE
193	STEAM CONDENSATE LEAK
194	STEAM CONDENSATE LEAK
195	NICKEL CARBONYL DISPOSAL
196	WATER TREATMENT PLANT BACKWASH POND
197	SCRAP METAL SITES
198	VOCs IN GROUND WATER
199	CONTAMINATION OF THE LAND SURFACE
200	GREAT WESTERN RESERVOIR
201	STANDLEY RESERVOIR
202	MOWER RESERVOIR
203	INACTIVE HAZARDOUS WASTE STORAGE AREA
204	ORIGINAL URANIUM CHIP ROASTER
205	BLDG 460 SUMP 43 ACID SIDE
206	INACTIVE D-836 HAZARDOUS WASTE TANK
207	INACTIVE 444 ACID DUMPSTER
208	INACTIVE 444/447 WASTE STORAGE AREA
209	SURFACE DISTURBANCE SOUTHEAST OF BLDG 881
210	UNIT 16, BUILDING 980 CARGO CONTAINER

TABLE A1 (cont)

INDIVIDUAL HAZARDOUS SUBSTANCE SITES

REF NO	SITE NAME
211	UNIT 26, BUILDING 881 DRUM STORAGE
212	UNIT 63, BUILDING 371 DRUM STORAGE
213	UNIT 15, 904 PAD PONDCRETE STORAGE
214	UNIT 25, 750 PAD PONDCRETE AND SALTCRETE STORAGE
215	UNITS 55 13, 55 14, 55 15, 55 16 - TANKS T-40, T-66, T-67, T-68
216	EAST SPRAY FIELDS
	216 1 NORTH AREA
	216 2 CENTER AREA
	216 3 SOUTH AREA
217	UNIT 32, BUILDING 881, CN- BENCH SCALE TREATMENT

EG&G ROCKY FLATS PLANT	**Manual:**	**5-21200-OPS**
EMAD MANUAL OPERATION SOP	**Procedure No**	**FO.14, Rev 1**
	Page:	**1 of 12**
	Effective Date.	**June 10, 1991**
Category 2	**Organization·**	**Environmental Management**

TITLE
DATA BASE MANAGEMENT

Approved By·

_________________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes procedures that will be used at the Rocky Flats Plant (RFP) to provide an orderly method by which field data will be recorded, entered into electronic form, validated, transferred, and filed This applies to field data generated by any field-related sampling activities performed for the Rocky Flats Environmental Management (EM) Program This procedure encompasses the data handling process from the point of data collection by field personnel to the filing and transmission of data to EG&G personnel

This SOP describes hardware and software requirements, field data collection, data entry, data validation, data archiving, and filing that will be used for field data collection and documentation to attain acceptable standards of accuracy, precision, comparability, representativeness, and completeness

3.0 RESPONSIBILITIES AND QUALIFICATIONS

The designated subcontractor has the overall responsibility for implementing this SOP. The subcontractor's project manager will be responsible for assigning project staff to implement this SOP and for assuring that the procedures are followed by all subcontractor personnel

The personnel responsible for maintaining the data in the data base shall have, at a minimum, a two-year degree in Computer Science or 4 years relevant experience, a working knowledge of DOS, data bases, Lotus 1-2-3, and personal computers If personnel are used who do not have this background, appropriate training will be provided by the sub-contractor

A designated EG&G subcontractor shall be responsible for maintaining the custom designed RFEDS data base This subcontractor will also provide timely updates and fixes to the software Any program updates will be provided to all subcontractors who are required to use the RFEDS data base.

4.0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure

A Compendium of Superfund Field Operations Methods EPA/540/P-87/001 December 1987

Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA Interim Final October 1988

RCRA Facility Investigation Guidance. (EPA). Interim Final May 1989

Rocky Flats Plant Environmental Restoration Program, Quality Control Plan Rockwell International January 1989

The Environmental Survey Manual DOE/EH-0053 Volumes 1-4 August 1987

Rocky Flats Environmental Data System, Users Manual Rockwell InternatioNal June 1990

4.2 INTERNAL REFERENCES

Related SOPs cross-referenced in this SOP are as follows

- SOP FO 13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples
- SOP GW 1, Water Level Measurements in Wells and Piezometers
- SOP GW 4, Collection of Tap Water Samples
- SOP GW 6, Groundwater Sampling
- SOP GW 8, Installation, Operation, and Sampling with Soil-Water Samplers
- SOP GT 1, Logging Alluvial and Bedrock Material
- SOP GT 2, Drilling and Sampling Using Hollow-Stem Auger Techniques
- SOP GT 4, Rotary Drilling and Rock Coring
- SOP GT 7, Logging of Test Pits and Trenches
- SOP GT 8, Surface Soil Sampling
- SOP GT 9, Soil Gas Sampling and Field Analysis
- SOP SW 4, Surface Water Discharge Measurements

5.0 PROCEDURES

This procedure is based primarily on the Rocky Flats Environmental Data System User's Manual and conversations held with representatives from EG&G

5.1 HARDWARE AND SOFTWARE REQUIREMENTS

The purpose of this section is to define the minimum computer system required for the entry and transfer of the field data to EG&G

- 80286 based micro computer
- 1 parallel port
- 5 1/4 high density disk drive or 3 1/2 high density disk drive
- 40 MB hard-disk drive
- EGA or VGA monitor and compatible drive
- 80-column printer
- 4MB RAM memory
- Autocad - version 10.0 or higher
- Oracle database software - version 5 1C or higher
- Lotus 1-2-3
- DOS, version 3.31 or higher
- Maynstream 60 tape drive backup or equivalent

These requirements may be changed, when necessary, by RFP to comply with their available data transfer needs RFP will inform all subcontractors of any necessary changes by way of a memo

5.2 FIELD DATA COLLECTION

All data collected from the field will be recorded on preprinted forms At a minimum, the sample number, site designation, and initials of the collector should be recorded on the form To the extent possible, the format of the form should be in the same order as the electronic form in the data base This should assist the field personnel in entering data into the data base with more efficiency and accuracy See Section 7 0 for samples of the field data forms

5.3 DATA RECEIPT AND COMPLETENESS CHECK

The purpose of the receipt and checking is to start the validation process by receiving and briefly reviewing the data The preliminary validation should be conducted as soon as possible after receipt of the completed data forms. This task ensures that the forms are complete before entry into the data base

- **The field data form should be delivered to the designated staff person by the field personnel by the end of each day of field operations**

- **The designated staff person receiving the form should initial and date the form upon receipt**

- Upon receipt, all forms should be checked for completeness The Site Supervisor should be consulted to verify that all of the field forms have been received At this time, any discrepancies should be discussed with the field personnel and clarified or completed immediately Any changes to the field forms will be initialed and dated by the person making the changes

- **The following forms should be included with the field data package**

  - **Field data transmittal form**
  - **Appropriate field data forms, depending on the sampling activity**

5.4 TECHNICAL DATA VALIDATION

When the data completeness has been verified, a technical validation should be performed on the data by a qualified validator. This person should be able to technically review the data to ensure that the data are consistent with known chemical and physical properties of the media being sampled For example, if the dissolved oxygen has a reading of 15, there is an indication of a problem since this is above the level of saturation The validator should check all calculations and reported units and all of the data on all of the forms. If the validator detects an error in the data report sheet, the validator must confer with the samples and the project manager prior to changing any information Any change made must be reflected in the project manager's logbook

5.5 DATA ENTRY

Once the field data have been reviewed and found to be complete, the data should be input to the Rocky Flats Environmental Data System (RFEDS) with the menu-driven data base program provided by International Technology Since this SOP is not intended to be a user's manual, please refer to the Rocky Flats Project Data base User's Manual for specific questions regarding the use of the data base software

Field tracking information should also be entered at this time into the Lotus 1-2-3 form provided by EG&G This form will track only a few pieces of data, including

- Sample number
- Sample location
- Bottle code and analyte
- Sampler's initials
- Date sampled
- Date shipped
- Lab
- Chain of custody number

5.6 DATA VALIDATION

This step ensures that the data recorded in the electronic data base are the same as the data recorded on the field data forms

5.6.1 Field Data

When all of the data for the day have been entered into the data base, the data should be printed using the report option of the data base program The reports should then be delivered along with the original field data forms to the designated data validation person Under no circumstance should the data validator be the same as the person who entered the data originally

The original field data form and the printed report should be compared for accuracy If transcription errors are found, the errors should be highlighted on the printed report and returned to the data entry person for corrections A new copy of the report should be generated at this time and the old copy destroyed This process should be repeated until the printed reports match the field data forms When the validation process is complete, the validator should initial and date both the original field forms and the printed report

5.6.2 Tracking Data

The next subtask is to enter the sample tracking information into the Lotus spreadsheet Always keep one copy of this Lotus form available in its original form This form should be used as a template and copied each week to a new file to be used that particular week

When all of the appropriate data are entered into the Lotus tracking form, it should be printed and given to the person responsible for validating the data. This subtask should be done at the same time as the field data reports Under no circumstance should the data validator be the same as the person who entered the data originally

When the validation process is complete, the printed form should be initialed and dated by the validator.

5.7 DATA ARCHIVING AND FILING

Upon completion of the daily validation, a copy of field data reports should be made The initialed, dated reports should then be filed with the original field data forms A copy of the initialed and dated computer printed report will be sent to EG&G in the weekly data package

At the end of each week, when all field data have been validated for the week, the data base should be archived by using the archive option The RFEDS program will make a copy of the electronic data on diskette This diskette is to be labeled with the type of data it contains e g soil boring data, well data, etc The tracking data should also have been validated at this point. A copy of the file containing the tracking data should also be made on diskette Be sure to use only 3½-inch double-sided, double-density diskettes for all disks to be sent to EG&G

The original data diskette containing the data base data, the tracking data diskette, along with all of the original data base reports and the field data transmittal forms should be hand-delivered to the designated EG&G representative A duplicate copy of these diskettes should be made at this time and filed with the original field data forms and the copies of the validated, initialed, and dated reports A paper copy of the tracking data is kept on file for quick reference

The original data base data remains on the hard disk in an archived form until the next set of data is archived At this point, the new archive will OVERWRITE the old archive. This is the primary reason for copying the data to a diskette at the same time as the diskette is prepared for EG&G. The computer will be backed up weekly, using a tape drive

5.8 SECURITY

The computers will be kept in a secure location and locked when not in use The data base itself will utilize a password security system The passwords required shall be known only to the personnel who enter the data onsite, the onsite manager, and a representative of EG&G

6.0 DOCUMENTATION

A permanent record of the implementation of this SOP will be kept by documenting field observations and data on field data forms, and validation observations in a data validation notebook Field observations and data will be recorded with black waterproof ink on field data forms Data validation observations will be recorded with black waterproof ink in a bound observation notebook with consecutively numbered pages Documentation of the validation of the data base and the tracking data should be recorded and include the following data

- Date of validation
- Initials of the validator
- Date delivered to EG&G

The task manager will be responsible for ensuring that this documentation is completed

See Section 7 0, Forms for examples of the data forms

7.0 FORMS

The following data management forms are the current RFEDS requested field data as of February 1991 Data are collected in compliance with the related SOP Each SOP will include a copy of the appropriate data forms Forms for the collection of soil and rock boring data have currently not been developed Those data base modules are currently in the process of completion

The current RFEDS data base does not address all the parameters which are collected in the field These additional parameters are in the field data sampling forms included in the cross-referenced SOPs Additions to the RFEDS program can capture and maintain this data

Included within this SOP are the following preliminary forms

- Form FO 14A Transmittal Form (RFEDS)

- Form FO 14B Groundwater Data Collection Form
- Form FO 14C Groundwater Level Measurement Data Collection Form
- Form FO 14D Sediment Data Collection Form
- Form FO 14E Surface Soil Data Collection Form
- Form FO 14F Sub-Surface Soil Data Collection Form
- Form FO 14G Surface Water Data Collection Form
- Form FO 14H Air Sampling Data Collection Form

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT FORM FO 14A

ROCKY FLATS ENVIRONMENTAL DATA SYSTEM
FIELD DATA TRANSMITTAL FORM

Type of Form (check one)

Soil Boring . . . . ☐
Rock Boring . . . . ☐
Groundwater Sampling . . . . ☐
Surface Water Sampling . . . . ☐
Sediment Sampling . . . . ☐
Groundwater Level Measurements . . . . ☐
Sub-Surface Soil Sampling . . . . ☐
Surface Soil Sampling . . . . ☐

Total Number of Forms ______ Sampler ______ (initials)

Sample # ________________ Location Code _______

Computer Entry and Validation

Data Entered by ____
Data Validation ____
Technical Validation ____

Delivery to EG&G

Received by _____

(4011-454)(FORM1.14A)(6/10/91)

Groundwater Sampling Field Data Collection Form

Sample Number ____________
Well Number ____________
Collection Date ____________ Quarter ______
Collection Time . . . . ____________
Type GW ____________

Purpose ____________
Collection Technique ____________
QC Type ____________ QC Partner ______
Volume Collected ____________ Units ______
Sample Team Leader ____________
Sample Team Member ____________
Sample Team Member ____________
Prepared By ____________

Purge Volume ____________ Units(gal/cu ft) ______
Purge Rate ____________ Units ______
Purging Method ____________
Depth to Water ____________ feet

Field Analytical Parameters

Specific Conductance ____________ uS/cm pH ______
Conductivity ____________ Units ____ eH ______
Conductivity Temp ____________ uS/cm pH ______
Sample Temp ____________ Units ____ eH ______ mV
Dissolved Oxygen ____________ mg/L Color ______
Headspace Reading ____________ Odor ______
Total Alkalinity ____________ mg/L Turbidity ______ NTU
Sample Filtered (Y/N) ____________ Nitrate ______ mg/L

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT

FORM FO 14C

GROUNDWATER LEVEL MEASUREMENT
FIELD DATA COLLECTION FORM

WELL NUMBER	DATE	DEPTH TO WATER (FT)	MEASURED BY (UP TO 25 CHARS)	COMMENTS (UP TO 50 CHARS)

(4011-454)(FORM1.14C)(6/10/91)

SEDIMENT FIELD DATA COLLECTION FORM

Sample No . . ________
Collection Date . . ________ Quarter. __
Collection Time . . ________
Type . . . . SD Purpose __
Location Code . . . . ________

North or Y . . . . : ________ East or X. ________

Sample Location . . . . : ________
Composite (Y/N) . . . __
Composite Description . . . . ________
QC Type . . . ________ QC Partner ________
Collection Method . . . . . ________
Sample Team Leader . . . . . : ________
Sample Team Member . . . : ________
Sample Team Member . . . . . ________
Volume Collected . . . . . : ________ Units ________
Prepared By . . . . ________

Depth of Water . . . . ________feet
Depth of Take . . . . . . : ________inches
Comments:________

Matrix ________
Request for Analysis No.: ________
Chain of Custody No. ________
Ship Date ________

Test Panels	Laboratory	Preservative	Due Date

Additional Comments ________

Signature of Observer ________ Time ______ Date ________

(4011-454)(FORM1 14D)(6/10/91)

SURFACE SOIL FIELD DATA COLLECTION FORM

Sample No . ________
Collection Date . ________ Quarter __
Collection Time . ________
Type . . . . . SO Purpose __
Location Code . . . ________

North or Y . . . . . . ________ East or X ________

Sample Location . . . . : ________
Composite (Y/N) . . : __
Composite Description . . . : ________
QC Type . ________ QC Partner ________
Collection Method . . . . : ________
Sample Team Leader . . . : ________
Sample Team Member . . . : ________
Sample Team Member . . : ________
Volume Collected . . . . : ________ Units ________
Prepared By . . . . . ________

Depth of Take . . . . Start End

Start		End	
________	feet	________	feet
________	feet	________	feet
________	feet	________	feet
________	feet	________	feet

Headspace Reading . . . . . : ________ ppm
Comments: ________

Matrix: ________
Request for Analysis No.: ________
Chain of Custody No.: ________
Ship Date: ________

Test Panels	Laboratory	Preservative	Due Date

Additional Comments ________

Signature of Observer ________ Time ____ Date ________

SUB-SURFACE SOIL FIELD DATA COLLECTION FORM

Sample No . . . . : ______________

Collection Date . . : ______________ Quarter: __

Collection Time . . ______________

Type . . . . : SB Purpose __

Location Code ______________

North or Y . . . . . . : ______________ East or X. ______________

Sample Location . . . . ______________

Composite (Y/N) . . . . : __

Composite Description . . . ______________

QC Type . . . . : ______________ QC Partner ______________

Collection Method . . . . ______________

Sample Team Leader . . . . . . ______________

Sample Team Member . . . . : ______________

Sample Team Member . . : ______________

Volume Collected . . . . : ______________ Units: ______________

Prepared By . . . . : ______________

Soil Type . . . . : ______________

Depth of Take . . . . : Start End

______ feet ______ feet

______ feet ______ feet

______ feet ______ feet

______ feet ______ feet

HNU Background . . . . : ______________ ppm

Reading . . . . : ______________ ppm

OVA Background . . . . . : ______________ ppm

Reading . . . . : ______________ ppm

Comments ______________

Matrix: ______________

Request for Analysis No : ______________

Chain of Custody No.: ______________

Ship Date. ______________

Test Panels	Laboratory	Preservative	Due Date

Additional Comments ______________

Signature of Observer: ______________ Time.______ Date ______________

SURFACE WATER DATA COLLECTION FORM

Sample No ______
Collection Date ______ Quarter __
Collection Time ______
Type SW Purpose __
Location Code ______

North or Y ______ East or X ______

Sample Location ______
Composite (Y/N) __
Composite Description ______
QC Type ______ QC Partner ______
Collection Method ______
Sample Team Leader ______
Sample Team Member ______
Sample Team Member ______
Volume Collected ______ Units ______
Prepared By ______

Stream Conditions
Type of Water Body ______ Dry (Y/N) __
Depth of Take ______ feet Stream Width __
Flow Rate ______ Total Depth __
Flow Rate Method ______

Field Analytical Parameters
Eh ______ mV Dissolved Oxygen ____ ppm
pH ______ Dissolved Oxygen Temp. __
Specific Conductance ______ umhos/cm Chlorine __
Air Temperature ______ (F/C) C End point #1 __
Sample Unit Temperature ______ (F/C) C End point #2 __
End point #3 __
Total Alkalinity __

Comments ______

Matrix ______
Request for Analysis No. ______
Chain of Custody No. ______
Ship Date ______

Test Panels	Laboratory	Preservative	Due Date

Additional Comments: ______

Signature of Observer ______ Time ____ Date ______

EG&G ROCKY FLATS PLANT	Manual:	5-21200-OPS
EMAD MANUAL OPERATION SOP	Procedure No.:	GT.1, Rev. 1
	Page:	1 of 36
	Effective Date:	June 10, 1991
Category 2	Organization:	Environmental Management

TITLE

LOGGING ALLUVIAL AND BEDROCK MATERIAL

Approved By:

______________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIXES

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) is part of the Rocky Flats Environmental Management (EM) Program Sampling Analysis Plan (SAP) The SAP includes the Quality Assurance Project Plan (QAPjP) and SOPs, which are program-wide documents that are not project-specific. These program-wide documents have been reviewed and approved by the Environmental Protection Agency (EPA) and the Colorado Department of Health (CDH) for EM activities at Rocky Flats

Project-specific requirements are described in individual project work plans that include a Field Sampling Plan (FSP) The FSP will include or reference the applicable program SOPs Procedural details not covered by the program-wide SOPs will be provided in SOP addenda (SOPAs) In general, an SOPA will conform with the original SOP but will be project-specific. The SOPAs will be an attachment to the FSP and must accompany the FSP and SOPs during field operations

The project-specific SOPAs, if required, will be prepared by the subcontractor designated to prepare the work plans

Over the period of the last few years, it has become apparent that a standardized procedure is needed for logging alluvial and bedrock material This need has arisen because each subcontractor has slightly different procedures and criteria for logging borehole material Beginning in 1991, all subcontractors will use the procedures that are covered in this SOP

By applying these techniques and procedures, it will be possible to standardize the logging of alluvial and bedrock materials In addition, the number of errors and the amount of relogging will be reduced This will allow lithologic descriptions to be compared from year to year and will enable the environmental management staff on the Rocky Flats Plant (RFP) site to make interpretations based on reliable data

On the RFP site, "alluvial material" includes alluvium, colluvium, fill, and agronomic soils Samples of alluvium, colluvium, fill, and agronomic soils are to be classified and described using the Unified Soil Classification System (U S C S) and enhanced by Item 10 1 in ASTM D2488, "Description and Identification of Soils (Visual-Manual Procedure) " Bedrock material, regardless of the degree of weathering, is to be classified and described by using many of the procedures and techniques described in Compton's "Manual of Field Geology" (1962), which has been incorporated with additional material in this SOP

3.0 RESPONSIBILITIES AND QUALIFICATIONS

The EG&G project manager has the overall responsibility for implementing this SOP The subcontractor's project manager will be responsible for assigning project staff to implement this SOP and for ensuring that the procedures are followed by all subcontractor personnel.

All personnel performing these procedures are required to have the appropriate health and safety training as specified in the site-specific Health & Safety Plan. In addition, all personnel are required to have a complete understanding of the procedures described within this SOP and receive specific training regarding these procedures, if necessary

Only qualified personnel will be allowed to perform these procedures Required qualifications vary depending on the activity to be performed In general, qualifications are based on education, previous experience, on-the-job training, and supervision by qualified personnel Personnel who log alluvial boreholes must study the RFP Alluvial Reference Set that contains examples of all 15 sample classifications within the U S C S System Personnel who log bedrock boreholes must be qualified geologists or geologic engineers, who have received special permission to log bedrock holes All of the loggers must study the Core Reference Set that contains 15 representative samples of the stratigraphic section in the RFP area In addition they must also study the Alluvial Reference Set These reference sets are used as training guides to help ensure consistency among logging geologists The subcontractor's project manager will document personnel qualifications related to this procedure in the subcontractor's project Quality Assurance (QA) files

All project staff are responsible for reporting deviations from this SOP to the individual's project manager The subcontractor's project manager will report deviations and nonconformances to the EG&G project manager

When field conditions require deviations from the SOP or SOPA, a Procedural Deviation Notice (PDN) will be authorized by an EG&G EMAD logging supervisor An EG&G ER Department Administrative Procedure outlines the PDN approval process

4.0 REFERENCES

4.1 SOURCE REFERENCES

ASTM Method for Particle - Size Analysis of Soils. Soil and Rock Dimensions, Stone and Geo-Synthetics Vol 04 08 Sec. D422. 1989

ASTM Practice for Description and Identification of Soils for Engineering Purposes (Visual-Manual Procedures): Soil and Rock Dimensions, Stone and Geo-Synthetics Vol. 04 08 Sec. D2488 1989

Blatt, H , Middleton, G , Murray, R Origin of Sedimentary Rocks Prentice-Hall 1972

Compton, Robert R Manual of Field Geology John Wiley & Sons, Inc 1962

Harlan, R L., Kolm, K.E , Gutentag, E D. Water-Well Design and Construction Development in Geotechnical Engineering, #60 Elsevier 1989

Krumbein, W C , Pettijohn, F.J Manual of Sedimentary Petrography Appleton-Century-Crofts 1966

Unified Soil Classification System Appendix A Characteristics of Soil Groups Pertaining to Embankments and Foundations, Appendix B. Characteristics of Soil Groups Pertaining to Roads and Airfields (U S) Army Engineer Waterways Experiment Station Vicksburg, MS 1960

5.0 CLASSIFICATION/DESCRIPTION

5.1 UNIFIED SOIL CLASSIFICATION SYSTEM (U.S.C.S)

The U S C S classification system will be used at RFP The U S C S , as used in this SOP, has been modified from the Army Corps of Engineers' Technical Memorandum No 3-357, "The Unified Soil Classification System" (1960) The liquid limit, dilatancy, and dry strength are not included because they are neither practical to do in the field nor applicable to hydrogeologic logging. A reprint of the U.S C.S is enclosed in Appendix GT 1A

5.1.1 Basis of Classification

The U S C S historically has been used to classify "soils" based on their textural properties, liquid limit, and organic content In the past the term "soil" has been used by engineers as a catchall term that includes all unconsolidated material Because engineers are concerned with how the soil behaves as a construction material, this all-inclusive approach has served them quite well

However, in this SOP, the U S C S will be applied only to alluvium, colluvium, fill, and agronomic soils This has been done to separate unconsolidated cover material from bedrock that has well-defined sedimentologic and depositional patterns, regardless of the degree to which the bedrock has been weathered In the RFP area, it is more important to determine the possible paths of groundwater movement based on geologic processes than it is to determine the engineering properties of weathered bedrock based on its physical behavior

5.1.2 **Texture**

5.1.2.1 Grain Size Scale

The U S C S has a grain size scale that is divided into four main categories (1) cobbles, (2) gravel, (3) sand, and (4) fines The gravel, sand, and fines are subdivided into coarse and fine gravel; coarse, medium, and fine sand, and silt and clay

Table GT 1-1 is a summary of the U S C S grain size scale as well as the Wentworth, Atterberg, and U S. Department of Agriculture grain size scales (Krumbein and Pettijohn 1966, and Compton 1962)

Neither the U.S C S. nor the U.S Department of Agriculture grain size scales have a common base However, both the Wentworth and the Atterberg grain size scales are geometric series with a base of 2 and 10, respectively

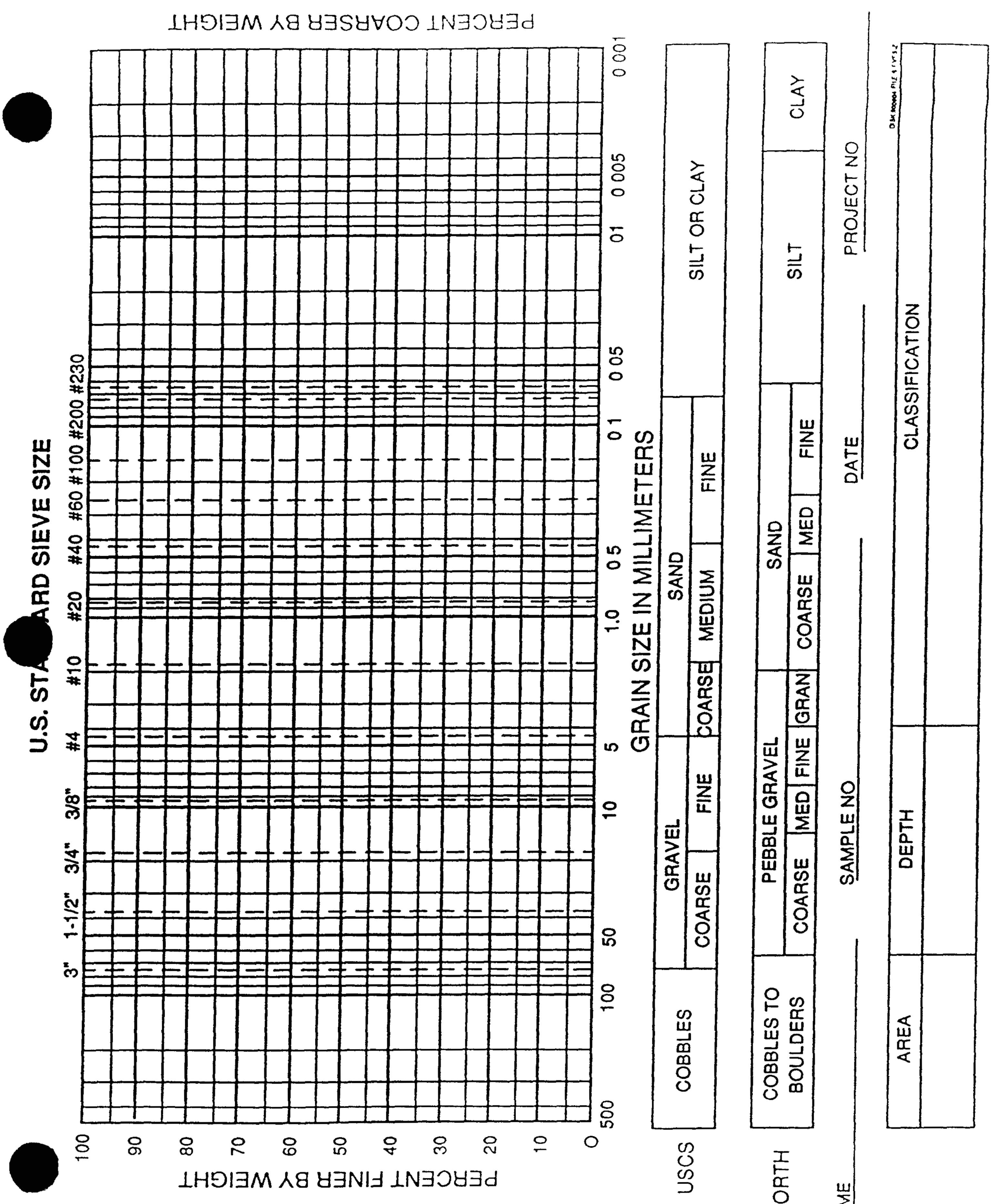
Finally, it should be noted that the division between sand and silt varies from scale to scale This makes it somewhat difficult to compare the U S C S grain size analyses with analyses based on other scales Most geotechnical laboratories show only the U S C S grain size ranges on the graph paper Figure GT 1-1 is a modified graph that shows both the U S C S and Wentworth grain size ranges ASTM D422, "Particle-Size Analysis of Soils," should be used to perform the grain size analyses but should be modified to include a 230 sieve

TABLE GT 1-1

Grain Size Scales (millimeter[mm])

U S C S	Wentworth	Atterberg	U S. Dept Ag	Component
>76 2	256-64	200-20	>80	Cobbles
–	64-32*	–	–	V C. Gravel
76.2-19	32-16*	–	–	C. Gravel
–	16-8*	20-2*	80-2	M Gravel
19-4 76	8-4*	–	–	F Gravel
–	4-2	–	–	Granule
–	2-1	–	2-1	V C. Sand
4 76-2	1-0.5	2-0 2	1-0.5	C. Sand
2-42	0.5-0.25	–	0.5-0.25	M Sand
42-074	0.25-0 125	0.2-0 02	0.25-0 1	F Sand
–	0.125-0 0625	–	0 1-0 05	V F Sand
< 074	0 0625-0 0039	0 02-0 002	0 05-0 002	Silt
–	<0 0039	<0 002	< 002	Clay
Variable	Base 2	Base 10	Variable	

*Pebbles



EG&G

U.S. STANDARD SIEVE SIZE

FIGURE GT 1-1

It is important to mention that a degree of error is inherent between all versions of grain size estimates made in the field and those that are made in the laboratory The field data are based on volumetric (visual) estimates while the laboratory data are derived from weight measurements In addition, it must be stressed that sieves and grain size charts should be used regularly whenever estimates are being made

5.1.2.2 Graded Material

The concept of graded material is used to describe the number of grain size ranges that are present within the central portion (approximately 80 percent) of the grain size distribution for samples with less than 5 percent fines (silt and clay) If a sample contains predominantly one or two grain- size ranges (such as medium and fine sand), it is poorly graded and has a symbol (P) If a sample contains several grain size ranges (such as fine gravel, coarse sand, medium sand, and fine sand), it is well graded and has a symbol (W)

Field values may be checked after the grain size analyses have been calculated and plotted. The uniformity coefficient is a useful value that may help determine whether a gravel or a sand is well graded The formula for the uniformity coefficient is

$$Uc = D60/D10$$

where the D values are read directly from the grain size plots and represent the amount of material that is finer by weight Well-graded gravels have a value greater than 4, and well-graded sands have a value greater than 6

5.1.3 Field Estimates of Plasticity

The plasticity characteristics of fine-grained alluvium or the fine fraction of a coarse alluvium should be determined per the procedures covered in the U S C S (Appendix GT 1A) The following paragraph and paragraph excerpts are taken from the U.S C S in Appendix GT 1A

"Particles larger than about the No 40 sieve size are removed (by hand), and a specimen of soil about the size of a 1/2-inch cube is molded to the consistency of putty If the soil is too dry, water must be added, and if it is sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. The sample is rolled by hand on a smooth surface or between the palms into a thread about 1/8 inches in diameter The thread is then folded and rerolled repeatedly During this manipulation, the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached. After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles The higher the position of the soil above the 'A' line on the plasticity chart the stiffer are the threads as their water content approaches the plastic limit and the tougher are the lumps as the soil is remolded after rolling."

5.1.3.1 Low Plasticity

Alluvial samples with a low plasticity "form a weak thread and . . . cannot be lumped together into a coherent mass below the plastic limit"

5.1.3.2 Medium Plasticity

Alluvial samples with a medium plasticity "form a medium tough thread (easy to roll) as the plastic limit is approached but when the threads are formed into a lump and kneaded below the plastic limit, the soil crumbles readily"

5.1.3.3 High Plasticity

Alluvial samples with a high plasticity form a stiff thread "as their water content approaches the plastic limit and the tougher are the lumps as the soil is remolded after rolling."

5.1.4 U.S.C.S. Sample Classification

The sample classifications of the U.S C.S are illustrated in Figure GT 1-2 In order to classify alluvium, colluvium, fill, and agronomic soils, it is necessary first to estimate the percent of all the grain size ranges in the sample and determine the plasticity of the fines if they comprise more than 50 percent of the sample. With this information, enter Figure GT 1-2 from the left and progress to the right matching the textural, plasticity, and organic characteristics of the sample

The progression through Figure GT.1-2 is an "if/then" sequence of decisions that ultimately leads to the proper sample classification Two examples follow

- Example 1 — Seventy-five percent of the material is greater than the No 200 sieve, 53 percent greater than the No 4 sieve (gravel), 22 percent is sand, and 25 percent is fines (10 percent silt and 15 percent clay) The proper classification for this sample is a clayey gravel with some silt and sand (GC)

- Example 2 — Eighty-five percent of the material is smaller than the No 200 sieve, 5 percent is gravel, 10 percent is sand, 30 percent is silt, and 55 percent is clay that has a low to medium plasticity The proper classification for this sample is a silty clay with a trace of gravel and some sand (CL)

SOIL TYPES

Major Divisions			Letter	Symbol	Description
Coarse Grained Soils More than 50% of material is larger than no 200 sieve size	Gravel and Gravely Soils More than 50% of coarse fraction retained on no 4 sieve	Clean Gravels (< 5% fines)	GW		Well graded gravels or gravel sand mixtures little or no fines Uc > 4 (lab only)
			GP		Poorly graded gravels or gravel sand mixtures little or no fines
		Gravels with Fines (> 12% fines)	GM		Silty gravels gravel-sand-silt mixtures
			GC		Clayey gravels gravel sand-clay mixtures
	Sand and Sandy Soils More than 50% of coarse fraction passed no 4 sieve	Clean Sand (< 5% fines)	SW		Well-graded sands or gravelly sands little or no fines Uc > 6 (lab only)
			SP		Poorly-graded sands or gravelly sands little or no fines
		Sands with Fines (> 12% fines)	SM		Silty sands sand silt mixtures
			SC		Clayey sands sand clay mixtures
Fine Grained Soils More than 50% of material is smaller than no 200 sieve size	Silts and Clays	Low Plasticity	ML		Inorganic silts and very fine sands rock flour silty or clayey fine sands or clayey silts with slight plasticity
			CL		Inorganic clays of low to medium plasticity, gravelly clays sandy clays silty clays lean clays
			OL		Organic silts and organic silty clays of low plasticity
		High Plasticity	MH		Inorganic silts micaceous or diatomaceous fine sand or silty soils
			CH		Inorganic clays of high plasticity fat clays
			OH		Organic clays of medium to high plasticity organic silts
Highly Organic Soils			PT		Peat humus swamp soils w[illegible] high organic contents

Note Dual Sym[illegible] are used to indicate borderline so[illegible] classifica[illegible] whose fines range from 5 to 12%

Unified Soil Classification System

FIGURE GT 1-2

Modified from "Wa[illegible] W[illegible] De[illegible] [illegible] Co[illegible] [illegible] Deve[illegible] [illegible]

Sample descriptions should be made in the following order

- Main textural classification with modifiers
- Color
- Grain size
- Grading
- Angularity (ASTM D2488)
- Plasticity
- Composition
- Bedding
- Moisture content
- Top of bedrock, if present

5.1.5 Problems With the U.S.C.S.

The following are problems that are intrinsic to the U S C S An obvious problem with the U.S C S. is that a change of one or two percent in coarse or fine material on either side of the 50 percent boundary may cause the sample classification to vary considerably For example, a clayey gravel (GC) or a clayey sand (SC) could easily change to a gravelly clay or a sandy clay with low plasticity (CL) or a sandy clay with high plasticity (CH) Clearly a classification system that is this sensitive is subject to errors, especially in the field

Another problem is that it is all but impossible to determine a liquid limit in the field For the purposes of this SOP, the liquid limit has been replaced by field estimate of plasticity (see Subsection 5 1.3)

The U S.C S also lacks the textural property of angularity that helps to determine the maturity of a sediment

Finally the U S C S is a purely descriptive classification that has been designed for construction purposes and concentrates heavily on the physical properties of clay Because of this, the U S C S has 15 sample classifications and is very cumbersome

5.2 BEDROCK DESCRIPTIONS

All bedrock material should be classified and described by using many of the procedures and techniques described in Compton (1962), which has been incorporated with additional material in this SOP

5.2.1 Basis of Classification

Compton classifies sedimentary rocks on the basis of their texture, fabric, and composition Rock descriptions such as conglomerate, sandstone, siltstone, and shale (claystone and mudstone) are textural classifications based solely on grain size When other properties like sorting, roundness, bed thickness and contacts, cross-stratification, color, composition, cement, porosity, and fossil content are included, it is possible to make interpretations of where, how, and under what conditions the sediments were deposited

5.2.2 Textural Parameters

5.2.2.1 Grain Size Scale

The Wentworth grain size scale is divided into six main categories (1) cobbles, (2) pebbles, (3) granules, (4) sand, (5) silt, and (6) clay The pebble and sand categories are subdivided into very coarse, coarse, medium, and fine pebbles; and very coarse, coarse, medium, fine, and very fine sand (see Table GT 1-1) The scale is a geometric series with a base of 2

Unlike the U S C S in which the sand/silt boundary occurs at 0 074 mm, the sand/silt boundary occurs at 0 0625 mm in the Wentworth scale Since geotechnical laboratories generally plot grain size analyses on graph paper that is compatible with the U S C S , it is important to ensure that they also include the range of Wentworth grain size intervals on the graph paper (Figure GT 1-1)

5.2.2.2 <u>Degree of Sorting</u>

Sorting is a measure of the extent to which a sediment has been winnowed or reworked during transport It also is a good indicator of the maturity of a sediment, the energy of the transporting agent, and the environment of disposition

In order to determine the degree of sorting, Compton (1962) states, "an estimate is made of the range of grain sizes that include the bulk (here 80 percent) of the detrital materials " It is then necessary to count the number of size ranges that are contained in the 80 percent sample (see Table GT 1-1) The number of size ranges is then compared with Figure GT 1-3 to determine the degree of sorting that describes the sample best

5.2.2.3 <u>Degree of Rounding</u>

Rounding is a measure of the amount of abrasion a grain has undergone However, it is <u>not</u> generally used to describe sediments that are much finer than sand, because grains finer than sand tend to have elastic collisions that do not affect the shape of the grain. Two properties that must be considered when estimating the degree of rounding are (1) the composition and (2) the original shape of the grain Rounding, like sorting, is a measure of the maturity of a sediment The shapes shown in Figure GT 1-4 should be used to estimate the degree of rounding of individual grains

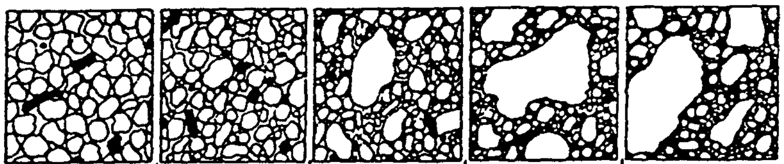


FIGURE GT.1-3

Terms for degrees of sorting The numbers indicate the number of size-classes included by the great bulk (80 percent) of the material The drawings represent sandstones as seen with a hand lens Silt and clay-size materials are shown diagramatically by the fine stipple Taken from Compton, 1962.

FIGURE GT.1-4

Terms for degree of rounding grains as seen with a hand lens After Powers, M C , 1953, "Journal of Sedimentary Petrology", v 23, p 118 Courtesy of the Society of Economic Paleontologists and Mineralogists Taken from Compton 1962

5.2.2.4 Porosity

Porosity is not always an easy property to estimate in the field because the bedrock can be drastically altered during drilling and coring as well as by weathering Generally, samples exhibit more porosity than the rock actually contains

Porosity should be expressed as a percentage An accurate estimate is important because the amount of porosity can give a general indication of the permeability of a rock

5.2.3 Estimate of Abundance

Figure GT 1-5 is composed of several drawings that represent the field of view commonly seen through a microscope or hand lens Each circle contains a number of black areas Below each circle is the actual percentage of black area that the circle contains All loggers should review Figure GT 1-5 until they are adept at estimating the percentages that are contained in the circles

5.2.3.1 Division of Abundance

Quite often it is necessary to determine the relative abundance of a variable In these cases, the use of the terms trace, some, and abundant has a utility The ranges for each are given in Table GT 1-2.

CHARTS FOR ESTIMATING PERCENTAG OMPOSITION OF ROCKS AND SEDIMEN

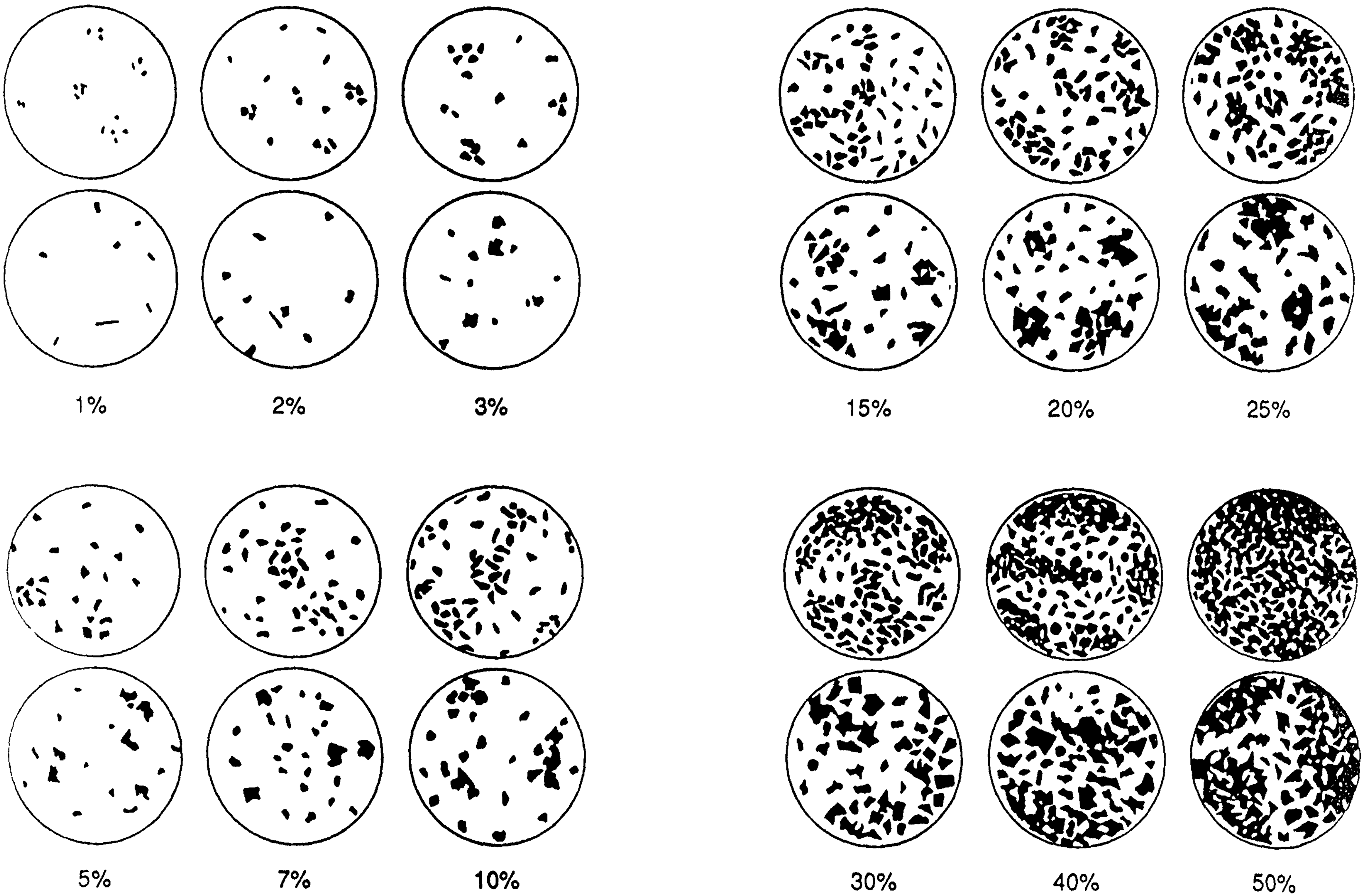


FIGURE GT.1-5

Prepared by R D Terry and G V Chilingar for "Journal of SedimentaryPetrology" (v 25, pp 229 234, 1955), reprinted as 'Data Sheet 6' of "Geotimes" available from the American Geological Institute, 2101 Constitution Ave , N W , Washington, D C Reprinted here by permission of the authors and the Society of Economic Paleontologists and Mineralologists Taken from Compton, 1962

(4011 REV)(GT1REV 1)(06/06/91)

TABLE GT 1-2
RANGE OF ABUNDANCE

Division	Range of Percent
Trace	>0 to 5
Some	6 to 25
Abundant	26 to 100

These terms generally follow a "with" statement, such as, Sandstone, light olive gray (5Y6/1), very fine to fine grained, with a trace of carbonaceous material

5.2.4 Color

Color can convey a great deal of information It helps to identify the components of the sediment or rock as well as the cement In addition, color can provide a fairly accurate idea of the current chemical environment from which the sample was taken For example, at RFP, highly weathered (oxidized) sandstones are commonly brownish-orange while unweathered sandstones are light olive grey

To ensure that the color descriptions are accurate and standardized, each sample should be described while it is wet by using the Geological Society of America "Rock-Color Chart" (1984) If the sample has dried, it should be moistened with clean water from a squirt bottle Care should also be taken to remove sunglasses when a color determination is being made

5.2.5 Rock Classification

Clastic rocks are primarily classified on the basis of their most frequent grain size The majority of rocks at RFP are claystone, siltstones, and sandstones, however, hybrids of these end members are quite common The second and sometimes third most frequent constituents act as modifiers and precede the major rock name in the description, such as, silty sandstone or clayey siltstone If, however, a rock is composed of 80 percent or more of one constituent, then it should be described solely as that rock type The secondary textural modifiers should then be described in the description following a "with" statement Figure GT 1-6 shows all the rock classifications and their lithologic symbols that should be used while logging bedrock samples

5.2.6 Cement

The nature of the cementing medium should be described whenever possible Typical cementing agents are clay (argillaceous cement), silica, and calcium carbonate (caliche)

5.2.7 Friability

The tendency of a rock to crumble is related to how well it is cemented and the extent to which it has been weathered. Table GT 1-3 shows the degree of friability

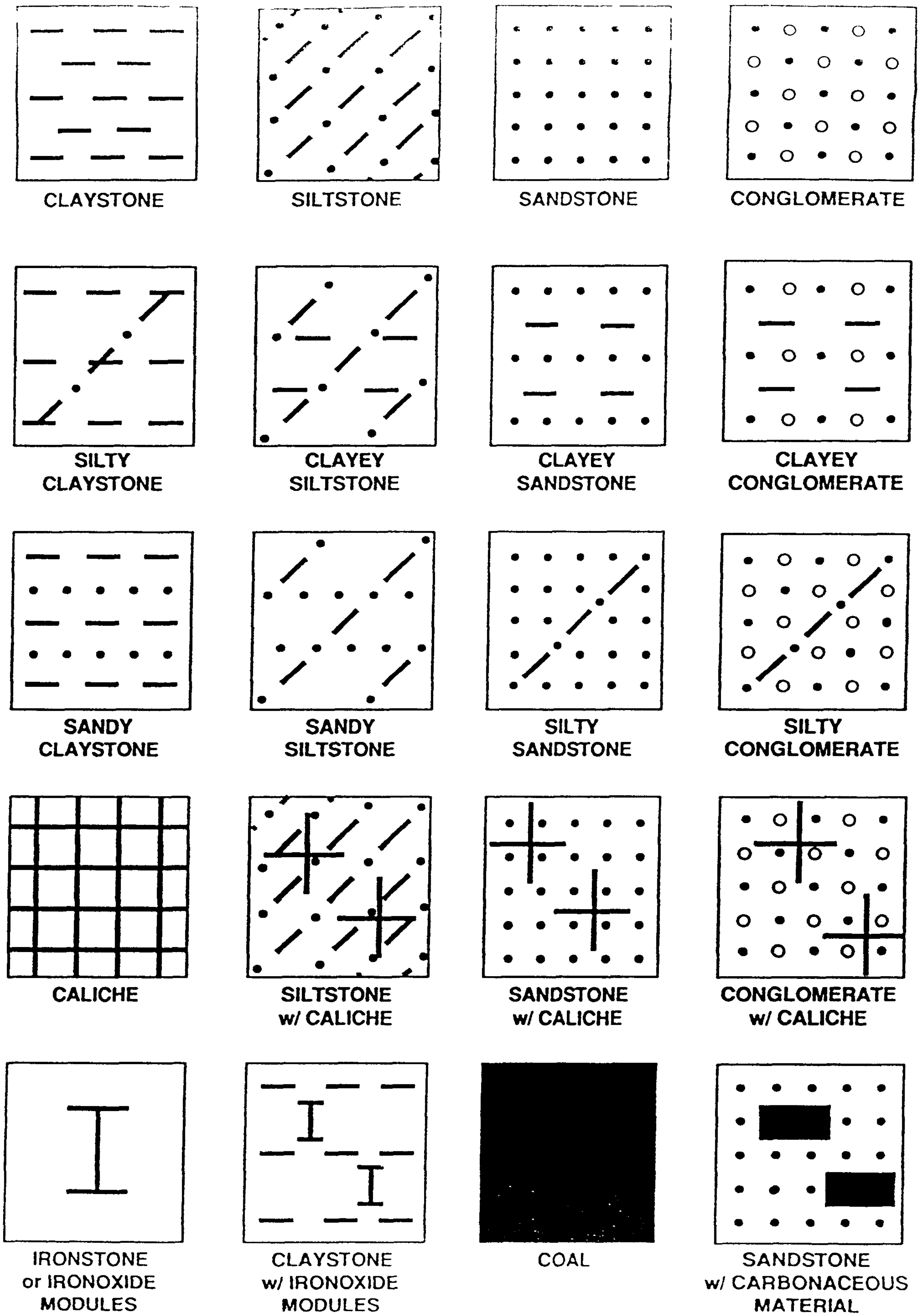


FIGURE GT 1-6 LITHOLOGIC SYMBOLS FOR COMMON CLASTIC ROCKS

TABLE GT 1-3

DEGREE OF FRIABILITY

Term	Definition
Highly Friable	Crumbles readily into individual grains upon minor disturbance
Moderately Friable	Will crumble into individual grains with extensive rubbing
Slightly Friable	Can be broken into individual grains by scraping it with a pocket knife
Non-Friable	Cannot be broken into individual grains by any of the methods described above

5.2.8 Composition

It is not the objective of this SOP to classify sedimentary rocks on the basis of their mineral content by using tertiary diagrams with quartz/chert, feldspar, and lithic fragments at each pole Since Compton wrote the "Manual of Field Geology" in 1962, several classifications have been published. Two of the most widely used classifications are those published by Earl McBride in 1963 and Robert Folk in 1974 Blatt, et al, (1972) presents an excellent evaluation of these and other classifications For the purpose of this SOP, the geologist is concerned with describing only accessory minerals, fossils, and other components that distinguish one rock from another The descriptive term(s) should follow a "with" statement, such as, silty sandstone, light olive grey (5Y6/1), very fine grained, with some pink feldspar rock fragments

5.2.9 Bedding and Internal Structure

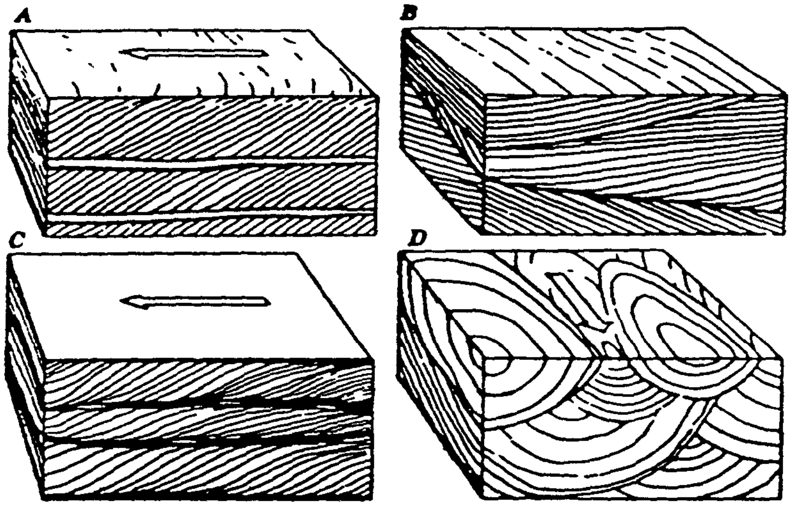
In sedimentary rocks, bedding is related to differences in texture, composition, and color, and reflects changes in the environment of deposition and/or the source material Depending on the depositional processes that are involved, bedding boundaries may or may not represent a specific moment in time

Compton classifies bedding as repeated sequences of beds, shapes of individual beds, and cross-bedding (cross-stratification) Repeated bedding is produced by cyclic changes in the sedimentary processes Individual bed shapes are classified as tabular, lenticular, linear, wedge-shaped, or irregular Cross-stratification is classified on the basis of its external and internal characteristics External forms of cross-stratification are tabular, wedge shaped, and trough shaped Internal descriptive terms that are commonly used are graded, massive, laminated, and tangential (Figure GT 1-7) Other internal features not related to bedding are ripple marks, flow structures, burrows and tubes, load casts, and desiccation cracks (mud cracks)

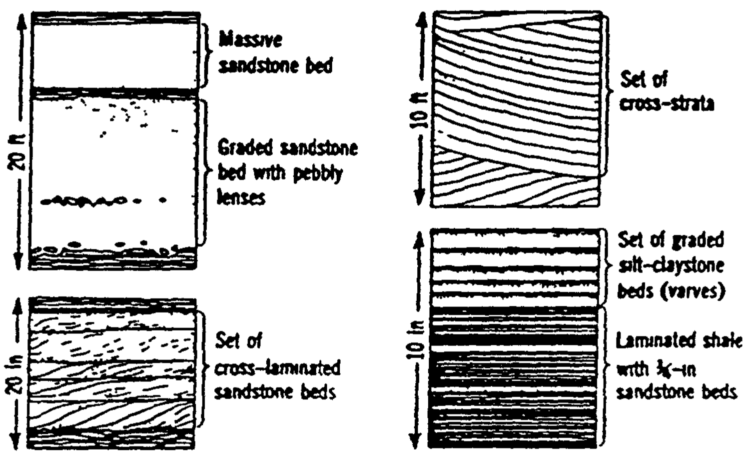
5.2.10 Fractures and Slickensides

Fractures should be described whenever they are present Fractures occur naturally in bedrocks and should not be confused with breaks induced by coring and handling The characteristics that should be noted about the fracture are

- Whether the fracture is opened or healed
- The composition of the material filling the fracture, if any
- The angle of the fracture from the horizontal
- The apparent displacement of bedding across the fracture
- Whether slickensides are present and the angle of any striations from the horizontal



Cross-bedded rocks (A) Tabular sets with diagonal patterns (B) Wedge sets, showing considerable erosion between each set. (C) Tabular to lenticular sets with tangential patterns; typically, these are laminated marine beds (D) Symetrical trough sets with distinctly linear axes, typically, these are large-scale fluvial features The arrows indicate current directions
Taken from Compton, 1962



Various beds and sets of beds Taken from Compton 1962

BEDDING AND INTERNAL STRUCTURES

FIGURE GT.1-7

5.2.11 Moisture Content

The core should be described as dry, moist, or saturated, and the depth to the top of the saturated interval should be recorded If a static water level can be measured, it should be noted also

5.2.12 Lithogic Description

Lithogic descriptions should be made in the following order

- Main rock type with modifiers
- Color
- Grain size
- Degree of sorting
- Degree of rounding
- Porosity
- Cement
- Friability
- Composition
- Bedding and internal structure
- Fractures and slickensides
- Moisture content
- Top of bedrock, if present

6.0 LOGGING

This section describes the field procedures used while logging

It is the responsibility of the logging personnel to ensure that all of the materials and equipment needed for logging are at the site

6.1 LOGGING EQUIPMENT

The following is a list of equipment that is necessary to properly log the alluvial and bedrock material

- Core Reference Set
- Alluvial Reference Set
- Rock-Color Chart
- Logging forms
- Hand lens
- Nos. 4, 40, 200, and 230 sieves (8-inch) with lid and base
- Six-foot metal measuring tape in tenths of a foot and tenths of an inch
- Core boxes (2 feet long, 5 columns each 2-1/2 inches wide) (such as, Boise Cascade No 17-505 top and bottom)
- Wood blocks (2-1/2 inches x 3/4 inches) for marking depths and sample locations
- Jars for cuttings
- Wentworth and/or Amstrat grain size charts
- Knife
- Acid (10 percent Hcl) in squirt bottle
- Water in squirt bottle
- Markers (black, waterproof)
- Protective clothing and equipment (see Health & Safety Plan)
- Pens (black, waterproof)
- Flashlight
- Hammer
- Clipboard
- Table

- Duct tape
- Paper towels
- Plastic wrap
- Protractor
- Camera (35 mm) with film (Kodak color patch)
- Flat-bladed screwdriver
- Awl
- Metal measuring tape in tenths of a foot

6.2 CORE BOXES

The core boxes should be similar to the boxes described in Subsection 6 1 above Each core box and lid should be marked with the following information

- Well name
- Location
- Surface elevation
- Depth interval
- Date
- Project number
- Logger's initials
- Box number and the total number of boxes
- Appropriate hazardous waste labels

After samples have been containerized, the remaining core will be placed in marked core boxes and moved to the core storage facility In addition to markings, the core boxes will be labeled and stored according to the results of field monitoring (organic vapor detectors and radiological screening) conducted during drilling and coring activities (See SOP FO.8, Handling of Drilling Fluids and Cuttings and SOP FO 16, Field Radiological Measurements)

Core boxes suspected of containing low-level radioactive substances only will be labeled with a "White I" radioactive label Core boxes suspected of containing volatile organic or mixed substances will be labeled with a Department of Transportation "Other Regulated Material Class E" (ORM-E) label (See SOP FO 10, Receiving, Labeling and Handling of Waste Containers) If the suspected contamination is mixed substances, the core box will also be marked with the words "SUS RAD" for suspected radioactive contamination

The core boxes will be then moved to the appropriate storage facility

6.3 CORES AND CUTTINGS

6.3.1 Scanning the Core

After an interval of core has been cut and the sampler has been opened, the core will be scanned for hazardous and radioactive contamination The field use of monitors for the detection of volatile organics and radionuclides is discussed in SOPs FO.8, Handling of Drilling Fluids and Cuttings, FO.15, Use of Photoionizing Detectors and Flame Ionizing Detectors, and FO 16, Field Radiological Instruments Once the core has been scanned, it will be handled in accordance with the Health and Safety Plan

6.3.2 Percent Recovery

The core should be consolidated in the sampler, measured, and if competent, the core will be etched with two parallel lines using an awl and a flat-bladed screwdriver The awl line will be etched on the left side of the core, for the entire length of the core The screwdriver line will be etched on the right side of the core, for the entire length of the core These etched lines denote the "up" position All competent core will be etched with enough pressure so the lines are readily visible, but not with enough pressure so the core's features are obliterated or altered Once etched, the core will be slid out onto the plastic wrap that has been placed in the core box. Immediately following this, the core should be measured to the nearest tenth of a foot, and this measurement, along with the interval that was cut, should be recorded on the logging form Figure GT 1-8 is an example of a completed logging form Wood blocks with footage values marked on them in black waterproof ink should be placed at each end of the core If only cuttings were collected, a representative sample should be collected every 2 feet, and this sample should be placed in a labeled jar in the core box.

If the core or drill cuttings are logged at a separate location removed from the drill site, the following information must be written on the logging form (Figure GT 1-8) and encosed in the core box:

- Interval cut and the amount of core recovered
- Drillers estimate of lithologic breaks
- Depth to water table if appropriate
- Intervals and type of sample taken

6.3.3 Logging

The core or cuttings should be logged according to all of the procedures previously covered in this SOP

ROCKY FLATS PLANT BOREHOLE LOG

Borehole Number 192-86
Location - North 749718.7 East 2086747.7
Date 10/26/86
Geologist. JBP
Drilling Equip : Continuous Core/Hollow Stem Auger

Surface Elevation 5962
Area East Trenches
Total Depth 30'
Company',
Sample Type S & H Sampler

Project No - 668-1211

EG&G LOGGING SUPERVISOR

APPROVAL ______________ DATE ______________

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG	SAMPLE DESCRIPTION
0'	0' / 5.5'	5.7'				80% Gravel	GW	0–5		Silty Sandy gravel; moderate brown (5 YR 4/4) to dusky yellowish brown (10 YR 2/2), gravel fragments to 4cm, medium- to coarse-grained Sand, trace fines, well graded, angular to subrounded, low plasticity, contains quartz and granite rock fragments, highly calcareous with caliche in the matrix at 2 to 3 feet, dry to moist, moderately weathered.
Box 1 of 3	5.5' / 6.2'							6		No Sample.
12'	6.2' / 10.3'	3.8'				75% Gravel	GP	7–9		Sandy gravel; moderate brown (5 YR 3/4) to dark yellowish brown (10 YR 4/2), broken gravel fragments to 15cm, medium- to coarse-grained Sand, poorly graded, angular to subrounded, low plasticity, Contains quartz and granite rock fragments, non stratified, moist, moderately.

EXAMPLE

NOTES General USCS is modified for this log as follows
Materials amounts are estimated by % volume instead of % weight
(*) Badly broken core accurate footage measurements not possible
(?) Core breaks cannot be matched accurate footage measurements not possible

Figure GT 1-8

ROCKY FLATS PLANT BOREHOLE LOG

Borehole Number 192-86
Location - North 749718 7 East 2086747 7
Date. 10/26/86
Geologist JBP
Drilling Equip.: Continuous Core/Hollow Stem Auger

Surface Elevation. 5962
Area East Trenches
Total Depth 30'
Company Acme Drilling Project No 662-12 11
Sample Type S&H Sampler

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG	SAMPLE DESCRIPTION
0'	6.2' / 10.3									Sandy gravel as above
Box 1 of 3	10.3'							11		No Sample
12' / 12'	12' / 12'	4.2'				85% Sand, <16% Silt		12, 13, 15, 16		Top of bedrock. Sandstone. light brown (5 YR 5/1) to yellowish brown (10 YR 4/2) to yellowish orange (10 YR 6/6), fine- to medium-grained, trace to some silt, well sorted, subrounded to rounded, highly friable, trace black grains, some very thin clay lenses at 14.5 and 15 feet, bedding not apparent, manganese staining throughout, slightly to moderately weathered.
Box 2 of 3	16.8' / 16.8'	3.8'				60% Sand, 35% Clay, 5% Silt		17, 18, 19		Clayey sandstone. light brown gray (5 YR 6/1) to brown gray (5 YR 4/1) fine- to medium-grained, moderately sorted, subrounded to rounded, abundant iron cementation, moderately to slightly friable, bedding not apparent, moist, slightly weathered.
24.4'	20.8'									

NOTES General USCS is modified for this log as follows
Materials amounts are estimated by % volume instead of % weight
(+) Easily broken core accurate footage measurements not possible
(-) Core breaks cannot be matched accurate footage measurements not possible

Figure GT 1-8

ROCKY FLATS PLANT BOREHOLE LOG

Borehole Number [illegible] | Surface Elevation 57[illegible]
Location - No [illegible] 749187 [illegible] 208[illegible]7417 | Area: East Trenches
Date 10/26/86 | Total Depth: 30'
Geologist JBP | Company: Acme Drilling | Project No 662-1211
Drilling Equip : Continuous Core/Hollow Stem Augers | Sample Type S&H Sampler

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG	SAMPLE DESCRIPTION
12'	16.8' / 20.2'									Clayey Sandstone as above with iron nodule at 20.4'.
Box 2 of 3 / 24.4'	20.3' / 24.4'	3.4'		85°, 80°		90% clay, 10% silt		21, 22, 23, 24		Claystone, olive gray (5Y 4/1) to olive black (5Y 2/1), bedding not apparent, brittle due to healed fractures with abundant slickensides at 80-85°, unweathered.
24.4' / Box 3 of 3 / 30'	24.4' / 30'	5.6'		45°, 75°		75% sand		26, 27, 28, 29		Sandstone, medium light gray (N 6/0), very fine-grained, well sorted, subrounded, well cemented, slightly friable, trough cross-stratification with sets ½ to 1 foot thick between 27 and 30 feet, fractures from 45° to 25°, some filled with calcareous material, dry to moist, unweathered.

EXAMPLE

NOTES General USCS is modified for this log as follows
Materials amounts are estimated by % volume instead of % weight
(1) Bad / broken core accurate footage measurements not possible
(2) Core ends cannot be matched accurate footage measurements not possible

Figure GT 1-8

6.3.4 Photographing the Core

Any and all photographing procedures must conform to plant security controls Each box of core should be photographed with a 35 mm camera after it has been logged and before the core is sampled If the core is photographed at RFP, the camera will have to be cleared and left on site until the project is completed In addition, all of the film must be processed by RFP An identification tag and a Kodak color patch should appear in each photograph The identification tag should contain

- The well name
- Footage values of the core in the box
- The box number of the total number of boxes for that borehole, such as Box 1 of 7
- Date core was taken
- Project number

6.3.5 Sampling

Samples that are taken for grain size analyses and permeameter tests should be removed only after the core has been logged and photographed At the time a sample is taken, a wood block with the following information must be placed in the core box at the point the sample was removed

- Sample number
- Depth
- Purpose
- Date
- Company

This information should be marked on the wood block with a black waterproof marker

7.0 DOCUMENTATION

A permanent record of the implementation of this SOP will be kept by documenting all information required by the SOP on the Borehole Log Form Drilling activities will also be documented on the hollow-stem auger or rotary and core drilling Field Activities Report Forms (see SOP GT 2, Drilling and Sampling Using Hollow-Stem Auger Techniques, and SOP GT 4, Rotary Drilling and Rock Coring)

The logger will primarily be responsible for each aspect and each procedure

ROCKY FLATS PLANT BOREHOLE LOG

Borehole Number
Location - North East
Date
Geologist
Drilling Equip.:

Surface Elevation
Area:
Total Depth:
Company: Project No :
Sample Type

EG&G LOGGING SUPERVISOR

APPROVAL ____________________ DATE ____________

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN BOX	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	LITHOLOGIC LOG	SAMPLE DESCRIPTION

NOTES General USCS is modified for this log as follows
Materials amounts are estimated by % volume instead of % weight.
(1) Badly broken core, accurate footage measurements not possible
(2) Core breaks cannot be matched, accurage footage measurements not possible

APPENDIX GT 1A

UNIFIED SOIL CLASSIFICATION SYSTEM

CHARACTERISTICS OF SOIL GROUPS

PERTAINING TO EMBANKMENTS AND FOUNDATIONS

AD/A026 473

THE UNIFIED SOIL CLASSIFICATION SYSTEM - APPENDIX A. CHARACTERISTICS OF SOIL GROUPS PERTAINING TO EMBANKMENTS AND FOUNDATIONS - APPENDIX B CHARACTERISTICS OF SOIL GROUPS PERTAINING TO ROADS AND AIRFIELDS

(U.S.) Army Engineer Waterways Experiment Station
Vicksburg, MS

Apr 60

TECHNICAL MEMORANDUM NO 3-357

THE UNIFIED SOIL CLASSIFICATION SYSTEM

APPENDIX A

CHARACTERISTICS OF SOIL GROUPS PERTAINING TO EMBANKMENTS AND FOUNDATIONS

APPENDIX B

CHARACTERISTICS OF SOIL GROUPS PERTAINING TO ROADS AND AIRFIELDS

April 1960
(Reprinted May 1967)

Sponsored by

Office, Chief of Engineers
U. S. Army

Conducted by

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

ARMY MRC VICKSBURG MISS

NOTICE

THIS DOCUMENT HAS BEEN REPRODUCED FROM THE BEST COPY FURNISHED US BY THE SPONSORING AGENCY. ALTHOUGH IT IS RECOGNIZED THAT CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED IN THE INTEREST OF MAKING AVAILABLE AS MUCH INFORMATION AS POSSIBLE.

Preface

The purpose of this manual is to describe and explain the use of the "Unified Soil Classification System" in order that identification of soil types will be on a common basis throughout the agencies using this system.

The program of military airfield construction undertaken by the Department of the Army in 1941 revealed at an early stage that existing soil classifications were not entirely applicable to the work involved. In 1942 the Corps of Engineers tentatively adopted the "Airfield Classification" of soils which had been developed by Dr. Arthur Casagrande of the Harvard University Graduate School of Engineering. As a result of experience gained since that time, the original classification has been expanded and revised in cooperation with the Bureau of Reclamation so that it applies not only to airfields but also to embankments, foundations, and other engineering features.

Acknowledgment is made to Dr. Arthur Casagrande, Professor of Soil Mechanics and Foundation Engineering, Harvard University, for permission to incorporate in this manual considerable information from the paper "Classification and Identification of Soils" published in Transactions, American Society of Civil Engineers, volume 113, 1948. This manual was prepared under the direction of the Office, Chief of Engineers, by the Soils Division, Waterways Experiment Station.

Contents

UNIFIED SOIL CLASSIFICATION SYSTEM

Introduction

Need for a classification system

1. The adoption of the principles of soil mechanics by the engineering profession has inspired numerous attempts to devise a simple classification system that will tell the engineer the properties of a given soil. As a consequence, many classifications have come into existence based on certain properties of soils such as texture, plasticity, strength, and other characteristics. A few classification systems have gained fairly wide acceptance, but it is seldom that any particular system has provided the complete information on a soil that the engineer needs. Nearly every engineer who practices soil mechanics will add judgment and personal experience as modifiers to whatever soil classification system he uses, so that it may be said that there are as many classification systems as there are engineers using them. Obviously, within a given agency, where designs and plans are reviewed by persons entirely removed from a project, a common basis of soil classification is necessary so that when an engineer classifies a soil as a certain type, this classification will convey to another engineer not familiar with the region the proper characteristics and behavior of the material. Further than this, the classification should reflect those behavior characteristics of the soil that are pertinent to the project under consideration.

Basis of the unified soil classification system

2. The unified soil classification system is based on the

embankments, foundations, roads, and airfields, is treated separately in appendices hereto which will be issued as the need arises. It is recognized that the unified classification system in its present form may not prove entirely adequate in all cases. However, it is intended that the classification of soils in accordance with this system have some degree of elasticity, and that the system not be followed blindly nor regarded as completely rigid.

Definitions of soil components

4. Before soils can be classified properly in any system, including the one presented in this manual, it is necessary to establish a basic terminology for the various soil components and to define the terms used. In the unified soil classification the names "cobbles," "gravel," "sand," and "fines (silt or clay)" are used to designate the size ranges of soil particles. The gravel and sand ranges are further subdivided into the groups presented below. The limiting boundaries between the various size ranges have been arbitrarily set at certain U. S. Standard sieve sizes in accordance with the following tabulation:

Component	Size Range
Cobbles	Above 3 in.
Gravel	3 in. to No. 4 (4.76 mm)
Coarse gravel	3 in. to 3/4 in.
Fine gravel	3/4 in. to No. 4 (4.76 mm)
Sand	No. 4 (4.76 mm) to No. 200 (0.074 mm)
Coarse sand	No. 4 (4.76 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine sand	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Fines (silt or clay)	Below No. 200 (0.074 mm)

These ranges are shown graphically on the grain-size sheet, plate 1. In classification criteria by which the various soil groups are identified and distinguished. Table 2 shows an auxiliary schematic method of classifying soils from the results of laboratory tests. The application and use of this chart are discussed in greater detail under a subsequent heading in this manual.

Soil groups and group symbols

6. Major divisions. Soils are primarily divided into coarse-grained soils, fine-grained soils, and highly organic soils. On a textural basis, coarse-grained soils are those that have 50 per cent or less of the constituent material passing the No. 200 sieve, and fine-grained soils are those that have more than 50 per cent passing the No. 200 sieve. Highly organic soils are in general readily identified by visual examination. The coarse-grained soils are subdivided into gravel and gravelly soils (symbol G), and sands and sandy soils (symbol S). Fine-grained soils are subdivided on the basis of the liquid limit; symbol L is used for soils with liquid limits of 50 and less, and symbol H for soils with liquid limits in excess of 50 (see plate 2). Peat and other highly organic soils are designated by the symbol Pt and are not subdivided.

7. Subdivisions, coarse-grained soils. In general practice there is no clear-cut boundary between gravelly soils and sandy soils, and as far as behavior is concerned the exact point of division is relatively unimportant. For purposes of identification, coarse-grained soils are classed as gravels (G) if the greater percentage of the coarse fraction (retained on No. 200 sieve) is larger than the No. 4 sieve and as sands (S) if the greater portion of the coarse fraction is finer than the No. 4

information should be evaluated and the soil classified as discussed subsequently under "Laboratory Identification." In areas subject to frost action, the material should not contain more than about 3 per cent of soil grains smaller than 0.02 mm in size. Typical examples of GW and SW soils are shown on plate 3.

GP and SP groups

10. Poorly-graded gravels and sands containing little or no nonplastic fines (less than 5 per cent passing the No. 200 sieve) are classed in the GP and SP groups. The materials may be classed as uniform gravels, uniform sands, or nonuniform mixtures of very coarse material and very fine sand, with intermediate sizes lacking (sometimes called skip-graded, gap-graded, or step-graded). The latter group often results from borrow excavation in which gravel and sand layers are mixed. If the fine fraction exhibits plasticity, this information should be evaluated and the soil classified as discussed subsequently under "Laboratory Identification." Typical examples of various types of GP and SP soils are shown on plate 4.

GM and SM groups

11. In general, the GM and SM groups comprise gravels or sands with fines (more than 12* per cent passing the No. 200 sieve) having low or no plasticity. The plasticity index and liquid limit (based on minus No. 40 sieve fraction) of soils in the group should plot below the "A" line on

* In the preceding two paragraphs soils of the GW, GP, SW, and SP groups were defined as having less than 5 per cent passing the No. 200 sieve. Soils which have between 5 and 12 per cent passing the No. 200 sieve are classed as "borderline" and are discussed in paragraph 33 under that heading.

predominantly silty materials and micaceous or diatomaceous soils. The symbols L and H represent low and high liquid limits, respectively, and an arbitrary dividing line between the two is set at a liquid limit of 50. The soils in the ML and MH groups are sandy silts, clayey silts, or inorganic silts with relatively low plasticity. Also included are loess-type soils and rock flours. Micaceous and diatomaceous soils generally fall within the MH group but may extend into the ML group when their liquid limit is less than 50. The same is true for certain types of kaolin clays and some illite clays having relatively low plasticity. Typical examples of soils in the ML and MH groups are shown on plate 7.

CL and CH groups

14. In these groups the symbol C stands for clay, with L and H denoting low or high liquid limit. The soils are primarily inorganic clays. Low plasticity clays are classified as CL and are usually lean clays, sandy clays, or silty clays. The medium and high plasticity clays are classified as CH. These include the fat clays, gumbo clays, certain volcanic clays, and bentonite. The glacial clays of the northern United States cover a wide band in the CL and CH groups. Typical examples of soils in these groups are shown on plate 8.

OL and OH groups

15. The soils in the OL and OH groups are characterized by the presence of organic matter, hence the symbol O. Organic silts and clays are classified in these groups. The materials have a plasticity range that corresponds with the ML and MH groups. Typical examples of OL and OH soils are presented on plate 9.

methods are entirely practical for preliminary laboratory identification and may be used to advantage in grouping soils in such a manner that only a minimum number of laboratory tests need be run.

General Identification

18. The easiest way of learning field identification of soils is under the guidance of experienced personnel. Without such assistance, field identification may be learned by systematically comparing the numerical test results for typical soils in each group with the "feel" of the material while field identification procedures are being performed.

Coarse-grained soils

19. Texture and composition. In field identification of coarse-grained materials a dry sample is spread on a flat surface and examined to determine gradation, grain size and shape, and mineral composition. Considerable experience is required to differentiate, on the basis of a visual examination, between well-graded and poorly-graded soils. The durability of the grains of a coarse-grained soil may require a careful examination, depending on the use to which the soil is to be put. Pebbles and sand grains consisting of sound rock are easily identified. Weathered material is recognized from its discolorations and the relative ease with which the grains can be crushed. Gravels consisting of weathered granitic rocks, quartzite, etc., are not necessarily objectionable for construction purposes. On the other hand, coarse-grained soils containing fragments of shaley rock may be unsuitable because alternate wetting and drying may result in their partial or complete disintegration. This property can be identified by a slaking test.

usually be detected by rubbing a sample between the fingers; silt or clay particles feel smooth and stain the fingers, whereas the sand feels gritty and does not leave a stain. The "teeth test" is sometimes used for this purpose, and consists of biting a portion of the sample between the teeth. Sand feels gritty whereas silt and clay do not; clay tends to stick to the teeth while silt does not. If there appears to be more than about 12 per cent of the material passing the No. 200 sieve, the sample should be separated as well as possible by hand, or by decantation and evaporation, removing all of the gravel and coarse sand, and the characteristics of the fine fraction determined. The binder is mixed with water and its dry strength and plasticity characteristics are examined. Criteria for dry strength are shown in column 5 of the classification sheet, table 1; evaluation of soils according to dry strength and plasticity criteria is discussed in succeeding paragraphs in connection with fine-grained soils. Identification of active cementing agents other than clay usually is not possible by visual and manual examination, since such agents may require a curing period of days or even weeks. In the absence of such experience the soils should be classified tentatively into their apparent groups, neglecting any possible development of strength because of cementation.

Fine-grained soils

21. The principal procedures for field identification of fine-grained soils are the test for dilatancy (reaction to shaking), the examination of plasticity characteristics, and the determination of dry strength. In addition, observations of color and odor are of value, particularly for organic soils. Descriptions of the field identification

particularly of the rock-flour type, also for diatomaceous earth (MH). The reaction becomes somewhat more sluggish with decreasing uniformity of gradation (and increase in plasticity up to a certain degree). Even a slight content of colloidal clay will impart to the soil some plasticity and slow up materially the reaction to the shaking test. Soils which react in this manner are somewhat plastic inorganic and organic silts (ML, OL), very lean clays (CL), and some kaolin-type clays (ML, MH). Extremely slow or no reaction to the shaking test is characteristic of all typical clays (CL, CH) as well as of highly plastic organic clays (OH).

23. Plasticity characteristics. Examination of the plasticity characteristics of fine-grained soils or of the fine fraction of coarse-grained soils is made with a small moist sample of the material. Particles larger than about the No. 40 sieve size are removed (by hand) and a specimen of soil about the size of a 1/2-in. cube is molded to the consistency of putty. If the soil is too dry, water must be added and if it is sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. The sample is rolled by hand on a smooth surface or between the palms into a thread about 1/8 in. in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached. After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles. The higher the position of a soil above the "A" line on the plasticity chart, plate 2 (CL, CH), the stiffer are the threads as their water content approaches the plastic limit and the tougher are the lumps as the

fraction of gravelly and sandy soils having a clay binder (GC and SC). Soils with high dry strength can be broken but cannot be powdered by finger pressure. High dry strength is indicative of most CH clays, as well as some organic clays of the OH group having very high liquid limits and located near the A-line. In some instances high dry strength in the undisturbed state may be furnished by a cementing material such as calcium carbonate or iron oxide.

25. Color. In field soil surveys color is often helpful in distinguishing between various soil strata, and to an engineer with sufficient preliminary experience with the local soils, color may also be useful for identifying individual soils. The color of the moist soil should be used in identification as soil color may change markedly on drying. To the experienced eye certain dark or drab shades of gray or brown, including almost black colors, are indicative of fine-grained soils containing organic colloidal matter (OL, OH). In contrast, brighter colors, including medium and light gray, olive green, brown, red, yellow, and white, are generally associated with inorganic soils. Use of the Munsell soil color charts and plates, prepared for the U. S. Department of Agriculture by the Munsell Color Company, Baltimore, Maryland, is suggested in the event more precise soil color descriptions are desired or to facilitate uniform naming of soil colors.

26. Odor. Organic soils of the OL and OH groups usually have a distinctive odor which, with experience, can be used as an aid in the identification of such materials. This odor is especially apparent from fresh samples. It gradually diminishes on exposure to air, but can be revived by heating a wet sample.

Identification of major soil groups

29. Reference to the identification procedure chart, table 2, shows that the first step in the laboratory identification of a soil is to determine whether it is coarse grained, fine grained, or highly organic. This may be done by visual examination in most cases, using the procedures outlined for field identification. In some borderline cases, as with very fine sands or coarse silts, it may be necessary to screen a representative dry sample over a No. 200 sieve and determine the percentage passing. Fifty per cent or less passing the No. 200 sieve identifies the soil as coarse grained, and more than 50 per cent identifies the soil as fine grained. The percentage limit of 50 has been selected arbitrarily for convenience in identification as it is obvious that a numerical difference of 1 or 2 in this percentage will make no significant change in the behavior of the soil. After the major group in which the soil belongs is established, the identification procedure is continued in accordance with the proper headings in the chart.

Identification of subgroups, coarse-grained soils

30. Gravels (G) or sands (S). A complete sieve analysis is run on coarse-grained soils and the gradation curve is plotted on a grain-size chart. For some soils containing a substantial amount of fines, it may be desirable to supplement the sieve analysis with a hydrometer analysis in order to define the gradation curve below the No. 200 sieve size. Preliminary identification is made by determining the percentage of material in the gravel (above No. 4 sieve) and sand (No. 4 to No. 200 sieve) sizes. If there is a greater percentage of gravel than sand the material is

that the grading curve will have a concave curvature within relatively narrow limits for a given D_{60} and D_{10} combination. All gradations not meeting the foregoing criteria are classed as poorly graded. Thus, poorly-graded soils (GP, SP) are those having nearly straight line gradations (plate 4, fig. 1, curve 3), convex gradations, nearly vertical (uniform) gradations (plate 4, fig. 1, curve 1), and gradation curves with "humps" typical of skip-graded materials (plate 4, fig. 1, curve 2).

32. GM, SM, GC and SC groups. The soils in these groups are composed of those materials having more than a 12* per cent fraction passing the No. 200 sieve; they may or may not exhibit plasticity. For identification, the liquid and plastic limits tests are required on the fraction finer than the No. 40 sieve. The tests should be run on representative samples of moist material, and not on air- or oven-dried soils. This precaution is desirable as drying affects the limits values to some extent as will be explained further in the discussion of fine-grained soils. Materials in which the liquid limit and plasticity index plot below the "A" line on the plasticity chart (plate 2) are classed as GM or SM (plate 5). Gravels and sands in which the liquid limit and plasticity index plot above the "A" line on the plasticity chart are classed as GC or SC (plate 6). It is considered that in the identification of materials in these groups the plasticity characteristics overshadow the gradation characteristics; therefore, no distinction is made between well- and poorly-graded materials.

---

* In the preceding paragraph soils of the GW, GP, SW, and SP groups were defined as having less than a 5 per cent fraction passing the No. 200 sieve. Soils having between 5 and 12 per cent passing the No. 200 sieve are classed as "borderline" and are discussed in paragraph 33.

CL and OL or ML soil types in this region is accomplished by a cross-hatched zone on the plasticity chart between 4 and 7 PI and above the "A" line. CL soils in this region are those having a PI above 7 while OL or ML soils are those having a PI below 4. Soils plotting within the cross-hatched zone should be classed as borderline as discussed later. The various soil groups are shown in their respective positions on the plasticity chart. Experience has shown that compressibility is approximately proportional to liquid limit and that soils having the same liquid limit possess approximately equal compressibility, assuming that other factors are essentially the same. On comparing the physical characteristics of soils having the same liquid limit, one finds that with increasing plasticity index, the cohesive characteristics increase and the permeability decreases. From plots of the results of limits tests on a number of samples from the same fine-grained deposit, it is found that for most soils these points lie on a straight line or in a narrow band approximately parallel to the "A" line. With this background information in mind, the identification of the various groups of fine-grained soils is discussed in the following paragraphs.

35. ML, CL, and OL groups. A soil having a liquid limit of less than 50 falls into the low liquid limit (L) group. A plot of the liquid limit and plasticity index on the plasticity chart will show whether it falls above or below the "A" line and cross-hatched zone. Soils plotting above the "A" line and cross-hatched zone are classed as CL and are usually typical inorganic clays (plate 8, fig. 1). Soils plotting below the "A" line or cross-hatched zone are inorganic silts or very fine sandy silts, ML (plate 7, fig. 1), or organic silts or organic silt-clays of low

highly organic soils (Pt) than has been stated previously under field identification. These soils are usually identified readily on the basis of color, texture, and odor. Moisture determinations usually show a natural water content of several hundred per cent, which is far in excess of that found for most soils. Specific gravities of the solids in these soils may be quite low. Some peaty soils can be remolded and tested for liquid and plastic limits. Such materials usually have a liquid limit of several hundred per cent and fall well below the "A" line on the plasticity chart.

Borderline classifications

38. It is inevitable in the use of the classification system that soils will be encountered that fall close to the boundaries established between the various groups. In addition, boundary zones for the amount of material passing the No. 200 sieve and for the lower part of the plasticity chart have been incorporated as a part of the system, as discussed subsequently. The accepted rule in classifying borderline soils is to use a double symbol; for example, GW-GM. It is possible, in rare instances, for a soil to fall into more than one borderline zone and, if appropriate symbols were used for each possible classification, the result would be a multiple designation consisting of three or more symbols. This approach is unnecessarily complicated and it is considered best to use only a double symbol in these cases, selecting the two that are believed most representative of the probable behavior of the soil. In cases of doubt the symbols representing the poorer of the possible groupings should be used.

39. Coarse-grained soils. It will be recalled that in previous

definitions of these terms are now somewhat different from those used by many soils engineers, it is considered advisable to discuss their connotation as used in this system. In the unified soil classification the terms "silt" and "clay" are used to describe those soils with Atterberg limits plotting respectively below and above the "A" line and cross-hatched zone on the plasticity chart. As a logical extension of this concept, the terms "silty" and "clayey" may be used as adjectives in the soil names when the limits values plot close to the "A" line. For example, a clay soil with LL = 40 and PI = 16 may be called a silty clay. In general, the adjective "silty" is not applied to clay soils having a liquid limit in excess of about 60.

Expansion of Classification

42. It may be necessary, in some cases, to expand the unified classification system by subdivision of existing groups in order to classify soils for a particular use. The indiscriminate use of subdivisions is discouraged and careful study should be given any soil group before such a step is adopted. In all cases subdivisions should be designated preferably by a suffix to an existing group symbol. The suffix should be selected carefully so that there will be no confusion with existing letters that already have meanings in the classification system. In each case where an existing group is subdivided, the basis and criteria for the subdivision should be explained in order that anyone unfamiliar with it may understand the subdivision properly.

belongs, it is usually an easy matter to select an appropriate name from the classification sheet. Some soils may be readily identified and properly named by only visual inspection. A word of caution is considered appropriate on the use of the classification system for certain soils such as marls, caliches, coral, shale, etc., where the grain size can vary widely depending on the amount of mechanical breakdown of soil particles. For these soils the group symbol and textural name have little significance and the locally used name may be important.

Other descriptive terms

45. Records of field explorations in the form of boring logs can be of great benefit to the engineer if they include adequate information. In addition to the group symbol and the name of the soil, the general characteristics of the soils as to plasticity, strength, moisture, etc., provide information essential to a proper analysis of a particular problem. Locally accepted soil names should also be used to clarify the data to local bidders, and to protect the Government against later legal claims. For coarse-grained soils, the size of particles, mineralogical composition, shape of grains, and character of the binder are relevant features. For fine-grained soils, strength, moisture, and plasticity characteristics are important. When describing undisturbed soils such characteristics as stratification, structure, consistency in the undisturbed and remolded states, cementation, drainage, etc., are pertinent to the descriptive classification. Pertinent items to be used in describing soils are shown in column 6 of table 1. In order to achieve uniformity in estimating consistency of soils, it is recommended that the Terzaghi classification based on unconfined compressive strength be

(Inc

Major Divisions			Group Symbols	Typical Names	Field Identificati (Excluding particles la and basing fract on on	
1	2		3	4	5	
Coarse grained Soils More than half of material is larger than No 200 sieve size	Gravels More than half of coarse fraction is larger than No 4 sieve size	Clean Gravels (Little or no fines)	GW	Well-graded gravels gravel-sand mixtures little or no fines	Wide range in grain sizes an amounts of all intermedia	
			GP	Poorly graded gravels or gravel-sand mixtures little or no fines	Predominantly one size or a some intermediate sizes m	
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels gravel-sand-silt mixture	Nonplastic fines or fines w (for identification proce	
			GC	Clayey gravels gravel-sand-clay mixtures	Plastic fines (for identifi see CL below)	
	Sands More than half of coarse fraction is smaller than No 4 sieve size (For visual classification, the 1/4 in size may be used as equivalent to the No 4 sieve size)	Clean Sands (Little or no fines)	SW	Well-graded sands gravelly sands little or no fines	Wide range in grain size an of all intermediate parti	
			SP	Poorly graded sands or gravelly sands little or no fines	Predominantly one size or a with some intermediate si	
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures	Nonplastic fines or fines w (for identification proce	
			SC	Clayey sands, sand-clay mixtures	Plastic fines (for identifi see CL below)	
The No 200 sieve size is about the smallest particle visible to the naked eye					Identification on Fraction Smaller than	
Fine grained Soils More than half of material is smaller than No 200 sieve size					Dry Strength (Crushing characteristics)	Dilatan (Reacti to shaki
	Silts and Clays Liquid limit is less than 50		ML	Inorganic silts and very fine sands rock flour, silty or clayey fine sands or clayey silts with slight plasticity	None to slight	Quick to s
			CL	Inorganic clays of low to medium plasticity gravelly clays, sandy clays, silty clays, lean clays	Medium to high	None to ve slow
			OL	Organic silts and organic silty clays of low plasticity	Slight to medium	Slow
	Silts and Clays Liquid limit is greater than 50		MH	Inorganic silts micaceous or diatomaceous fine sandy or silty soils elastic silts	Slight to medium	Slow to no
			CH	Inorganic clays of high plasticity, fat clays	High to very high	None
			OH	Organic clays of medium to high plasticity organic silts	Medium to high	None to ve slow
Highly Organic Soils			Pt	Peat and other highly organic soils	Readily identified by colo and frequently by fibrou	

(1) Boundary classifications: Soils possessing characteristics of two groups are designated by combinations of grou

FIELD IDENTIFICA

These procedures are to be performed on the minus N screening, it not intended simply

Dilatancy (reaction to shaking)

After removing particles larger than No 40 sieve size prepare a pat of moist soil with a volume of about one-half cubic inch Add enough water if necessary to make the soil soft but not sticky

Place the pat in the open palm of one hand and shake horizontally striking vigorously against the other hand several times A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy When the sample is squeezed between the fingers the water and gloss disappear from the surface the pat stiffens and finally it cracks or crumbles The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction Inorganic silts, such as a typical rock flour show a moderately quick reaction

Dry Strength (crushing cha

After removing particles
cons stency of putty
by oven sun or air-dr
between the fingers
the colloidal fraction
increasing plasticity

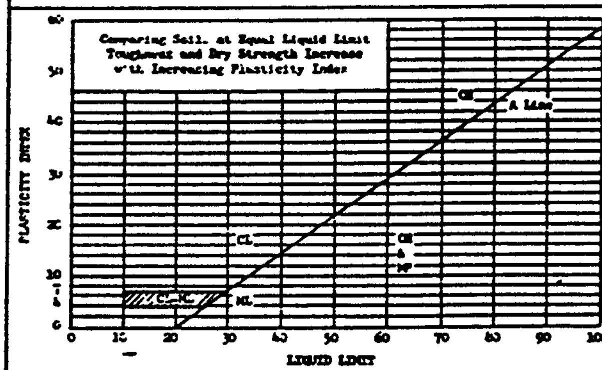
High dry strength is cha
ganic silt possesses or
have about the same ali
when powdering the drie
has the smooth feel of

31 A.

Table 1

UNIFIED SOIL CLASSIFICATION
(Including Identification and Description)

Field Identification Procedures (Excluding particles larger than 3 in and basing fractions on estimated weights)	Information Required for Describing Soils	Laboratory Classification Criteria			
5	6	7			
..e range in grain sizes and substantial amounts of all intermediate particle sizes	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics.	Use grain size curve in identifying the fractions as given under field identification	Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows: Less than 5% GW, GP, SW, SP; More than 12% GM, GC, SM, SC; 5% to 12% Borderline cases requiring use of dual symbols	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
..dominantly one size or a range of sizes with some intermediate sizes missing				Not meeting all gradation requirements for GW	
..plastic fines or fines with low plasticity (for identification procedures see ML below)	Give typical name; indicate approximate percentages of sand and gravel, maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.			Atterberg limits below "A" line or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
..stic fines (for identification procedures see CL below)				Atterberg limits above "A" line with PI greater than 7	
..e range in grain size and substantial amounts of all intermediate particle sizes				$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
..dominantly one size or a range of sizes with some intermediate sizes missing	Example: Silty sand, gravelly; about 20% hard angular gravel particles 1/2-in. maximum size; rounded and subangular sand grains, coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM)			Not meeting all gradation requirements for SW	
..plastic fines or fines with low plasticity (for identification procedures see ML below)				Atterberg limits below "A" line or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
..stic fines (for identification procedures see CL below)				Atterberg limits above "A" line with PI greater than 7	

Identification Procedures on Fraction Smaller than No. 40 Sieve Size			Information Required	Laboratory Criteria
..y Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)		
..e to slight	Quick to slow	None	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.	
..ium to high	None to very slow	Medium		
..ght to ..dium	Slow	Slight	Give typical name; indicate degree and character of plasticity; amount and maximum size of coarse grains; color in wet condition; odor if any; local or geologic name and other pertinent descriptive information; and symbol in parentheses.	
..ht to ..um	Slow to none	Slight to medium		
..h to very high	None	High		
..m to high	None to very slow	Slight to medium	Example: Clayey silt, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (ML)	
..ily identified by color, odor, spongy feel ..d frequently by fibrous texture				

PLASTICITY CHART

For laboratory classification of fine-grained soils

..) combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U. S. standard.

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

..formed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes ..not intended, simply remove by hand the coarse particles that interfere with the tests.

..Strength (crushing characteristics)

..ter removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely ..y oven, sun, or air-drying, and then test its strength by breaking and crumbling ..etween the fingers. This strength is a measure of the character and quantity of ..he colloidal fraction contained in the soil. The dry strength increases with ..ncreasing plasticity.

..h dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts ..ave about the same slight dry strength, but can be distinguished by the feel ..hen powdering the dried specimen. Fine sand feels gritty whereas a typical silt ..as the smooth feel of flour.

Toughness (consistency near plastic limit)

After particles larger than the No. 40 sieve size are removed, a specimen of soil about one-half inch cube in size, is molded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

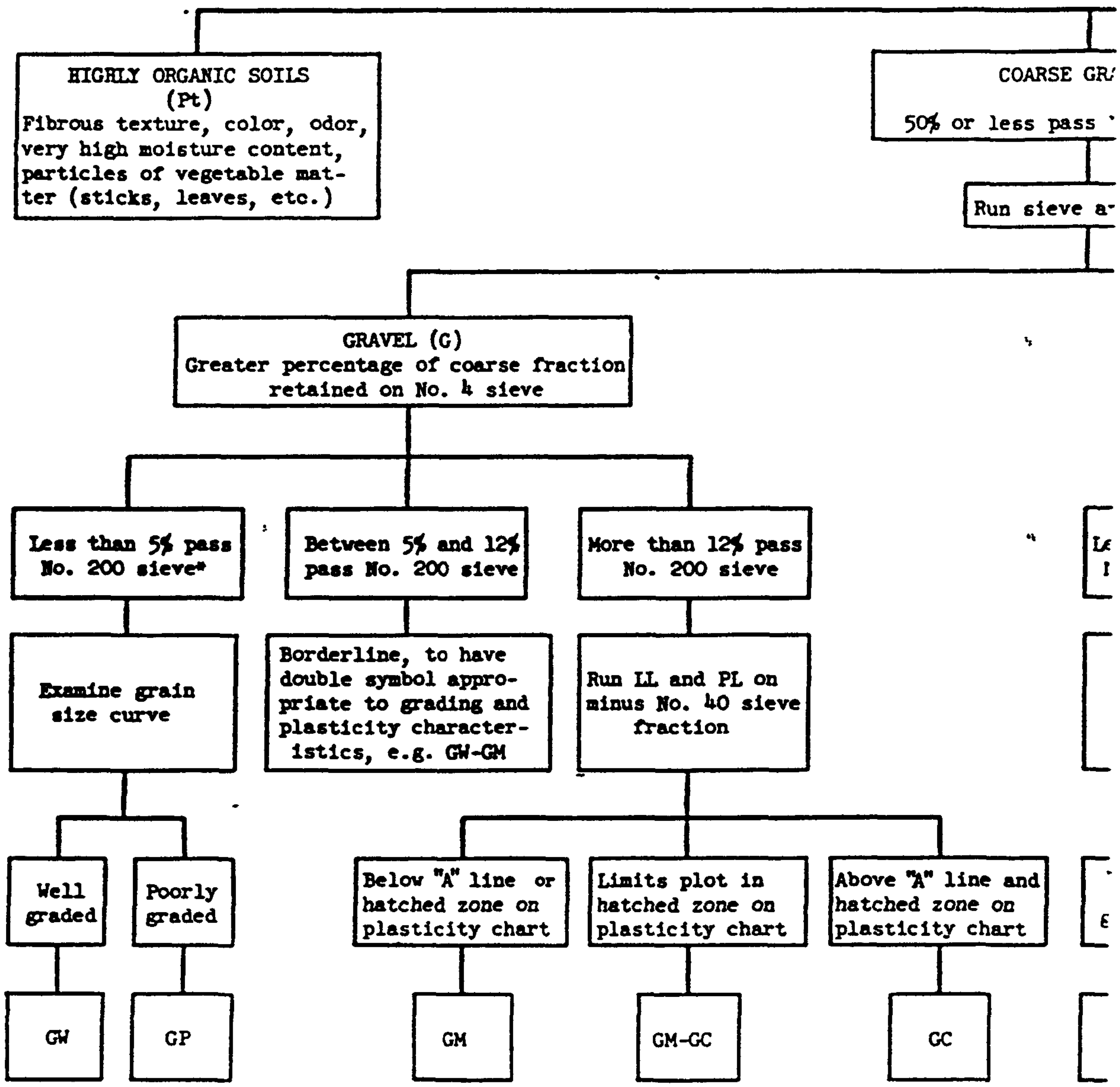
After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

021260A

31a



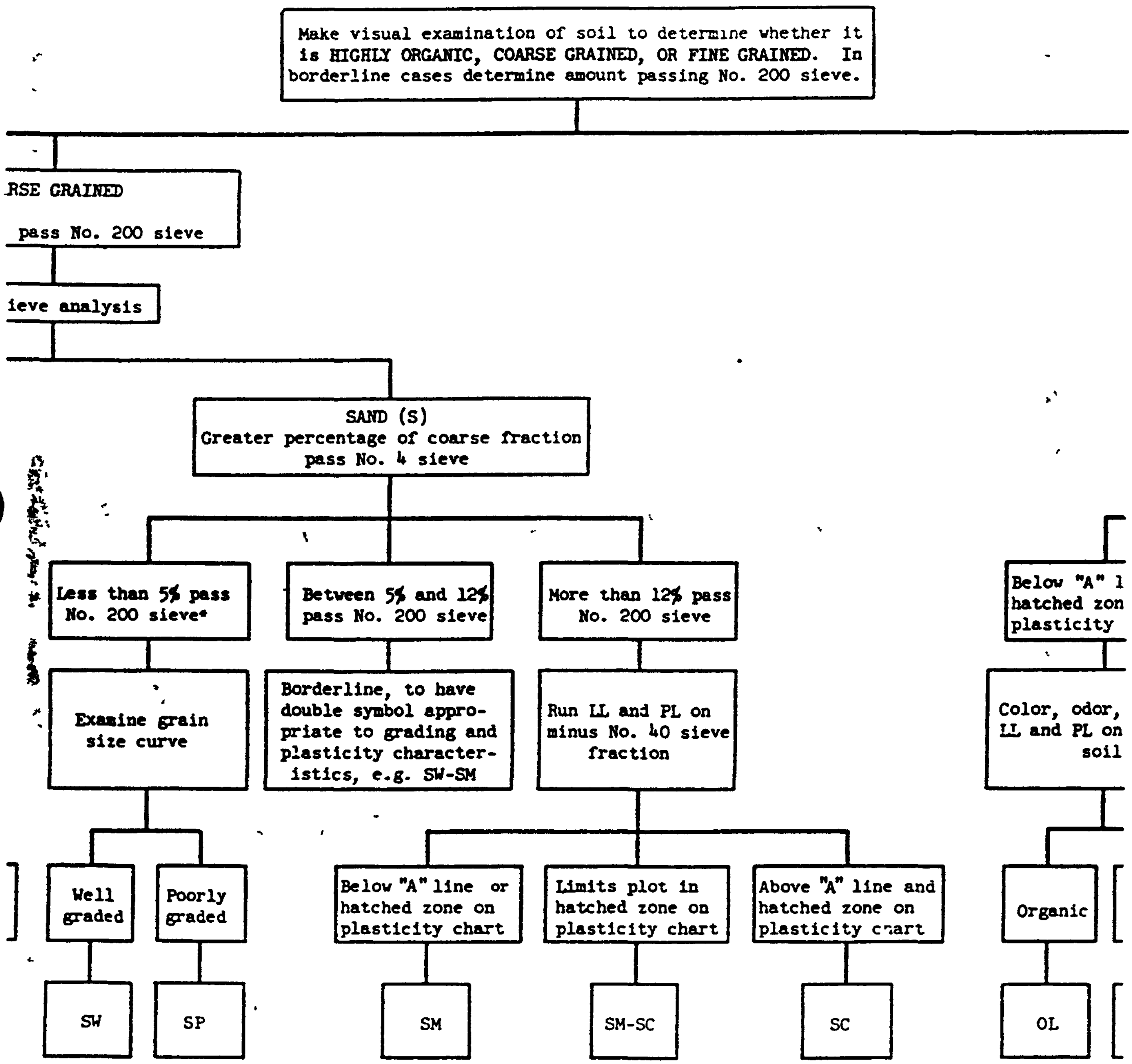
Note: Sieve sizes are U. S. Standard

* If fines interfere with free draining properties use double symbol such as GW-GM, etc.

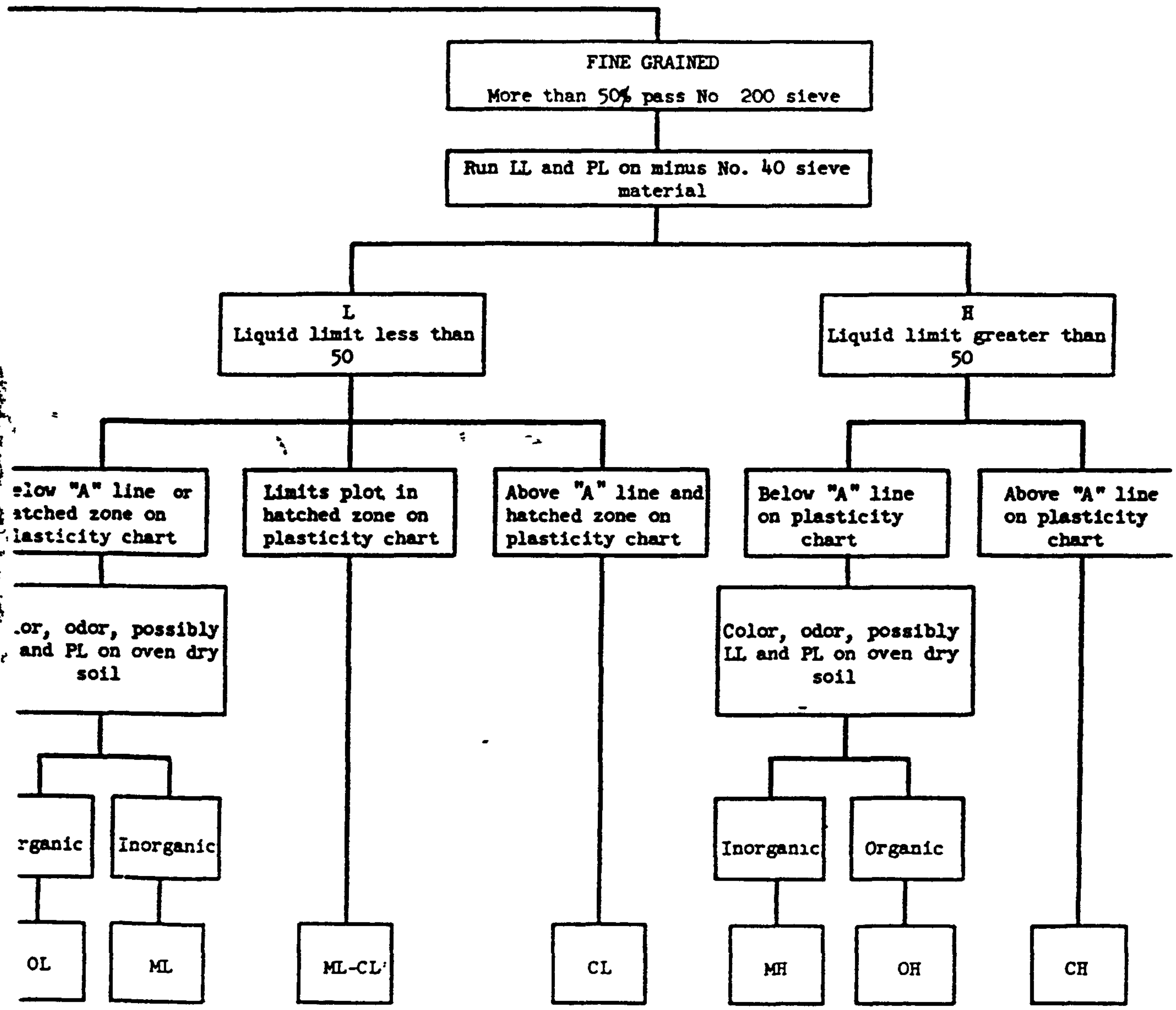
021260-B

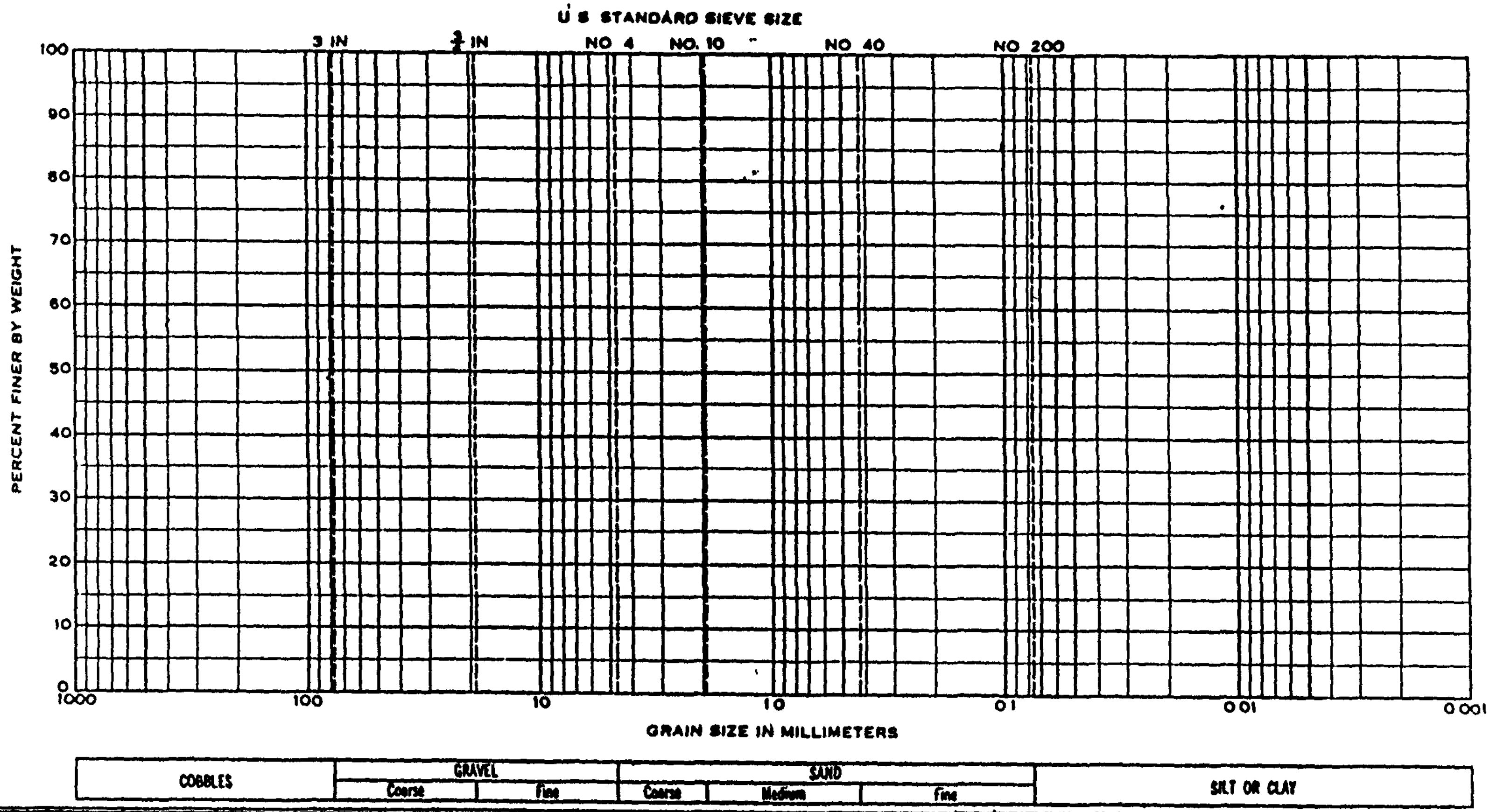
Table 2

AUXILIARY LABORATORY IDENTIFICATION PROCEDURE



tc.


FINE GRAINED
More than 50% pass No 200 sieve
Run LL and PL on minus No. 40 sieve material
L
Liquid limit less than 50
H
Liquid limit greater than 50
elow "A" line or atched zone on lasticity chart
Limits plot in hatched zone on plasticity chart
Above "A" line and hatched zone on plasticity chart
Below "A" line on plasticity chart
Above "A" line on plasticity chart
or, odor, possibly and PL on oven dry soil
Color, odor, possibly LL and PL on oven dry soil
rganic
Inorganic
Inorganic
Organic
OL
ML
ML-CL
CL
MH
OH
CH



Sample No	Elev or Depth	Classification	Nat WC	LL	PL	PI	

Project

Area

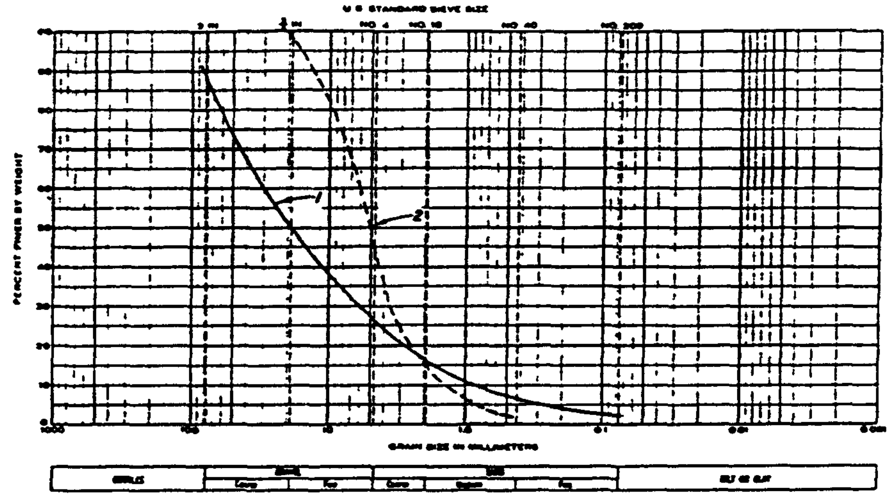
Boring No

Date

062552 C

GRADATION CURVES

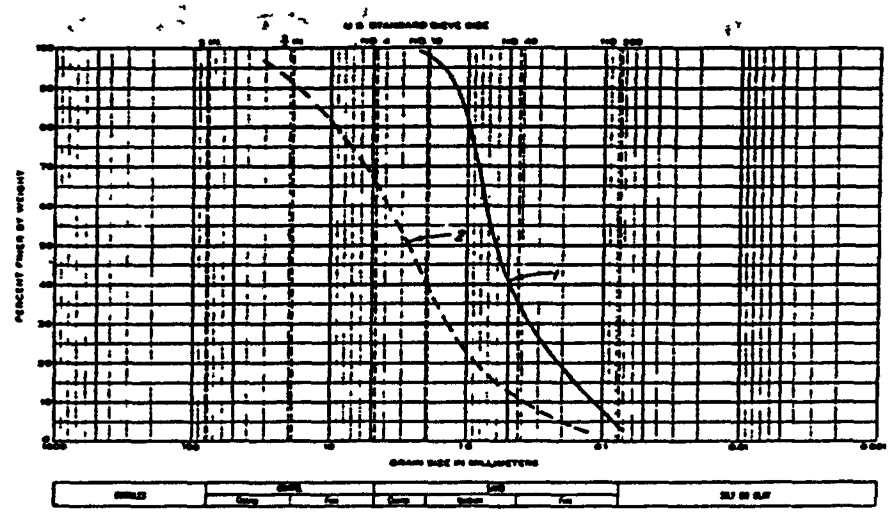
PLATE I



CURVE 1 Pit run gravel nonplastic, well-graded, small percentage of fines
CURVE 2 Sandy gravel; nonplastic; no fines Curve is about the steepest one that will meet the criteria for GW group

GW GROUP

FIG 1



CURVE 1 Medium to fine sand, nonplastic well-graded Curve is about the steepest one that will meet the criteria for SW group
CURVE 2 Gravelly sand; nonplastic, well-graded

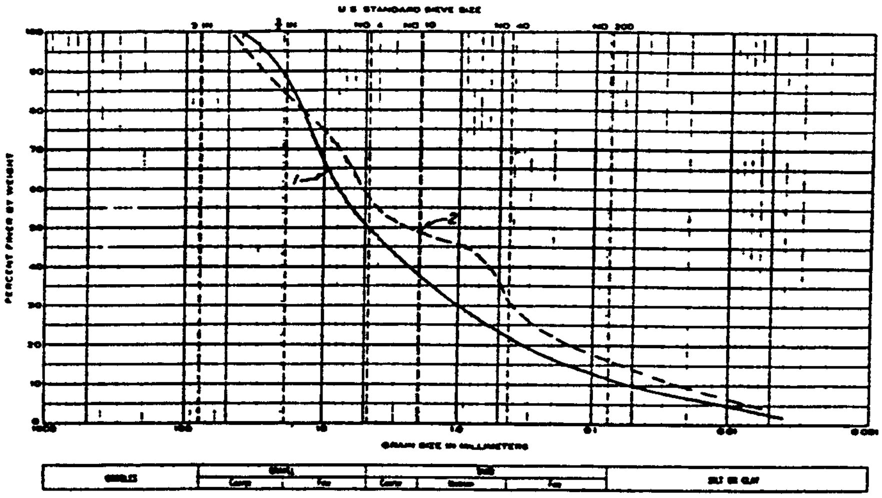
SW GROUP

FIG 2

TYPICAL EXAMPLES
GW AND SW SOILS

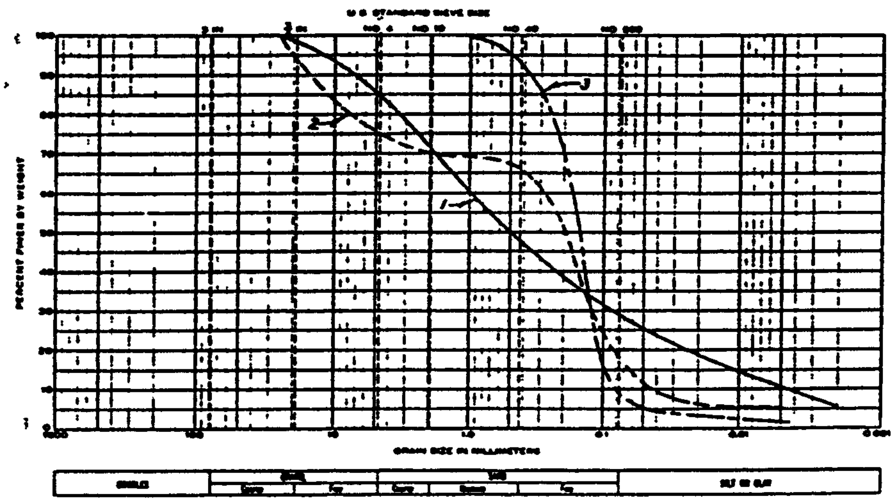
062852-A

PLATE 3



CURVE 1 Crushed limestone, LL-16 PI-2 Well-graded Made excellent base course material
CURVE 2 Gravel-sand-silt mixture LL-32, PI-6 Poorly graded

GM GROUP
FIG 1

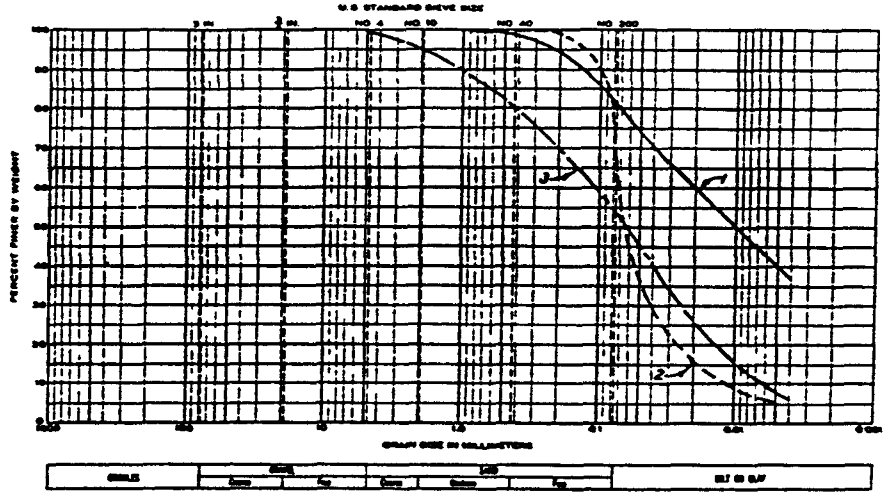


CURVE 1 Silty gravelly sand, nonplastic Micaceous silt stabilized with sandy chert gravel
CURVE 2 Mixture of gravel-sand and fine silty sand nonplastic Poorly graded mixture; note absence of coarse and medium sand
CURVE 3 Silty fine sand, LL-22, PI-5 Uniform gradation, amount passing No 200 sieve, and Atterberg limits classify soil as borderline in SP-SM SC groups Classify as SP-SM

SM GROUP
FIG 2

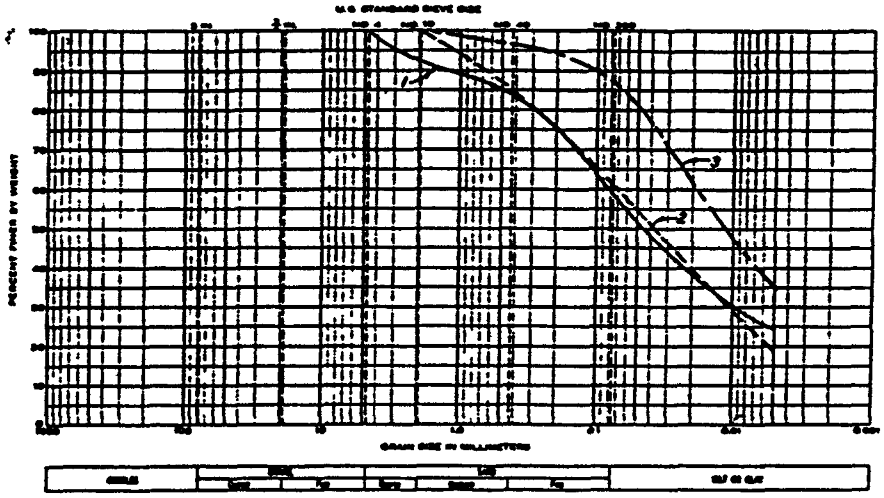
TYPICAL EXAMPLES
GM AND SM SOILS

062852-C



CURVE 1 Clayey silt, LL-46, PI-16
CURVE 2 Uniform sandy silt, LL-30 PI-3
CURVE 3 Sandy silt; LL-34 PI-3
GENERAL Note curves 2 and 3 have about the same plasticity but vary in grain size distribution

ML GROUP
FIG. 1



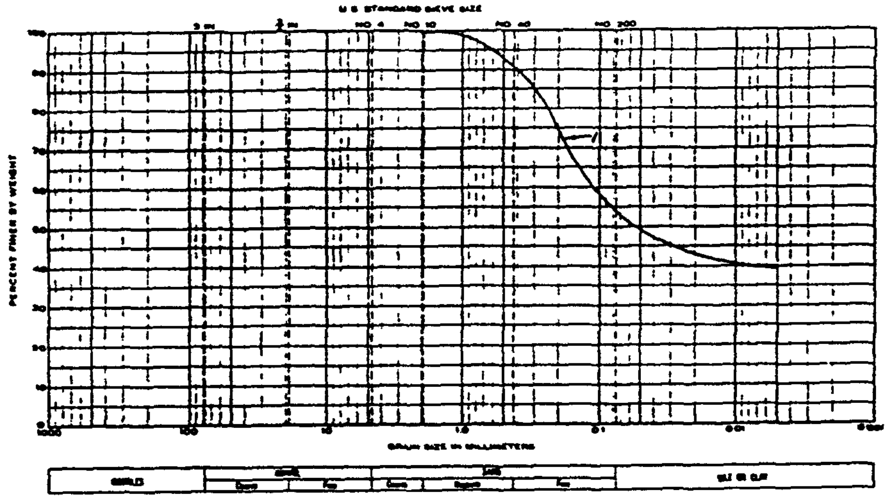
CURVE 1 Micaceous sandy silt, LL-55, PI-6
CURVE 2 Sandy silt; LL-67, PI-27
CURVE 3 Clayey silt, LL-54, PI-24
GENERAL. Note curves 1 and 2 have approximately the same grain size but are widely different in plasticity

MH GROUP
FIG 2

TYPICAL EXAMPLES
ML AND MH SOILS

062852-C

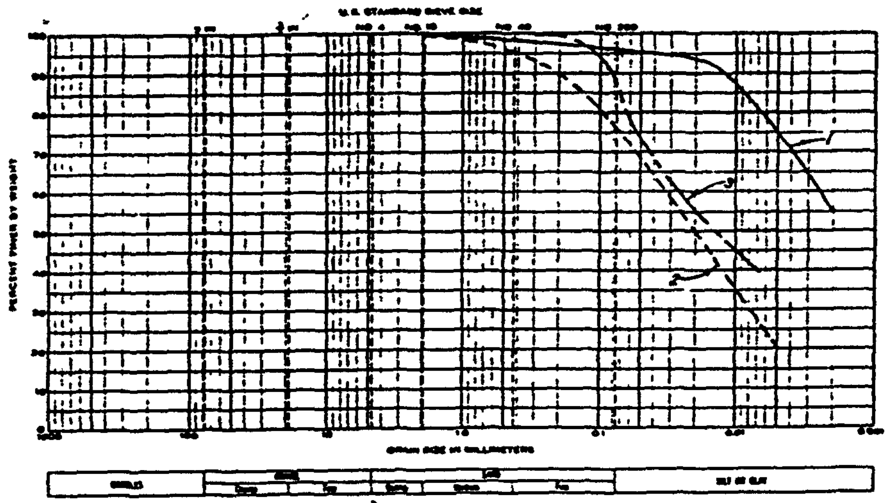
PLATE 7



CURVE 1 Organic sandy clay LL-46 PI 15

OL GROUP

FIG 1



CURVE 1 Organic clay (tidal flats), LL-95, PI-39
CURVE 2 Alkali clay with organic matter, LL-66, PI-27
CURVE 3 Organic silt LL-70, PI-33 (natural water content) LL-53, PI-19 (oven dried)

OH GROUP

FIG 2

TYPICAL EXAMPLES
OL AND OH SOILS

002852-C

TECHNICAL MEMORANDUM NO 3-357

APPENDIX A
CHARACTERISTICS OF SOIL GROUPS PERTAINING TO EMBANKMENTS AND FOUNDATIONS

March 1953

Sponsored by

Office, Chief of Engineers
U. S. Army

Conducted by

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

A-1

Contents

UNIFIED SOIL CLASSIFICATION SYSTEM

APPENDIX A

CHARACTERISTICS OF SOIL GROUPS PERTAINING TO EMBANKMENTS AND FOUNDATIONS

Introduction

1. The major properties of a soil proposed for use in an embankment or foundation that are of concern to the design or construction engineer are its strength, permeability, and consolidation and compaction characteristics. Other features may be investigated for a specific problem, but in general some or all of the properties mentioned above are of primary importance in an earth embankment or foundation project of any magnitude. It is common practice to evaluate the properties of the soils in question by means of laboratory or field tests and to use the results of such tests as a basis for design and construction. The factors that influence strength, consolidation, and other characteristics are numerous and some of them are not completely understood; consequently, it is impractical to evaluate these features by means of a general soils classification. However, the soil groups in a given classification do have reasonably similar behavior characteristics, and while such information is not sufficient for design purposes, it will give the engineer an indication of the behavior of a soil when used as a component in construction. This is especially true in the preliminary examination for a project when neither time nor money for a detailed soils testing program is available.

2. It should be borne in mind by engineers using the classification

characteristics; column 11, the suitability of the soils for foundations (strength and consolidation); and column 12, the requirements for seepage control, especially when the soils are encountered in the foundation for earth embankments (permeability). Brief discussions of these features are presented in the following paragraphs.

Suitability of soils for embankments

4. Three major factors that influence the suitability of soils for use in embankments are permeability, strength, and ease of compaction. The gravelly and sandy soils with little or no fines, groups GW, GP, SW, and SP, are stable, pervious, and attain good compaction with crawler-type tractors and rubber-tired rollers. The poorly-graded materials may not be quite as desirable as those which are well graded, but all of the materials are suitable for use in the pervious sections of earth embankments. Poorly-graded sands (SP) may be more difficult to utilize and, in general, should have flatter embankment slopes than the SW soils. The gravels and sands with fines, groups GM, GC, SM, and SC, have variable characteristics depending on the nature of the fine fraction and the gradation of the entire sample. These materials are often sufficiently impervious and stable to be used for impervious sections of embankments. The soils in these groups should be carefully examined to insure that they are properly zoned with relation to other materials in an embankment. Of the fine-grained soils, the CL group is best adapted for embankment construction; the soils are impervious, fairly stable, and give fair to good compaction with a sheepsfoot roller or rubber-tired roller. The MH soils, while not desirable for rolled-fill construction, may be utilized in the core of hydraulic-fill structures. Soils of

allowable because pool levels must be maintained. The more impervious soils (GM, GC, SM, SC, CL, MH, and CH) may be used in core sections or in homogeneous embankments to retard the flow of water. Where it is important that seepage not emerge on the downstream slope or the possibility of drawdown exists on upstream slopes, more pervious materials are usually placed on the outer slopes. The coarse-grained, free-draining soils (GW, GP, SW, SP) are best suited for this purpose. Where a variety of materials is available they are usually graded from least pervious to more pervious from the center of the embankment outward. Care should be used in the arrangement of materials in the embankment to prevent piping within the section. The foregoing statements do not preclude the use of other arrangements of materials in embankments. Dams have been constructed successfully entirely of sand (SW, SP, SM) or of silt (ML) with the section made large enough to reduce seepage to an allowable value without the use of an impervious core. Coarse-grained soils are often used in drains and toe sections to collect seepage water in downstream sections of embankments. The soils used will depend largely upon the material that they drain; in general, free-draining sands (SW, SP) or gravels (GW, GP) are preferred, but a silty sand (SM) may effectively drain a clay (CL, CH) and be entirely satisfactory.

7. Seepage through foundations. As in the case of embankments, the use of the structure involved often determines the amount of seepage control necessary in foundations. Cases could be cited where the flow of water through a pervious foundation would not constitute an excessive water loss and no seepage control measures would be necessary if adequate provisions were made against piping in critical areas. If seepage control

Therefore a positive cutoff may not be required and an upstream blanket, wells, or a toe trench may be entirely effective. In some cases a combination of blanket and trench or wells may be desirable. Silty soils -- silty gravels (GM), silty sands (SM), and silts (ML) -- usually do not require extensive treatment; a toe drainage trench or well system may be sufficient to reduce uplift pressures. The more impervious silty materials may not be permeable enough to permit dangerous uplift pressures to develop and in such cases no treatment is indicated. In general, the more impervious soils (GC, SC, CL, OL, MH, CH, and OH) require no treatment for control of uplift pressures. However, they do assume importance when they occur as a relatively thin top stratum over more pervious materials. In such cases uplift pressures in the lower layers acting on the base of the impervious top stratum can cause heaving and formation of boils; treatment of the lower layer by some of the methods mentioned above is usually indicated in these cases. It is emphasized that control of uplift pressures should not be applied indiscriminately just because certain types of soils are encountered. Rather, the use of control measures should be based upon a careful evaluation of conditions that do or can exist, and an economical solution reached that will accomplish the desired results.

Compaction characteristics

9. In column 9 of the table are shown the general compaction characteristics of the various soil groups. The evaluations given and the equipment listed are based on average field conditions where proper moisture control and thickness of lift are attained and a reasonable number of passes of the compaction equipment is required to secure the

(CL) being the best, fat clays and lean organic clays or silts (OL and CH) fair to poor, and organic or micaceous soils (MH and OH) usually poor. For most construction projects of any magnitude it is highly desirable to investigate the compaction characteristics of the soil by means of a field test section. In column 10 of table A1 are shown ranges of unit dry weight of the soil groups for the standard AASHO (Proctor) compactive effort. It is emphasized that these values are for guidance only and design or construction control should be based on laboratory test results.

Suitability of soils for foundations

10. Suitability of soils for foundations of embankments or structures is primarily dependent on the strength and consolidation characteristics of the subsoils. Here again the type of structure and its use will largely govern the adaptability of a soil as a satisfactory foundation. For embankments, large settlements may be allowed and compensated for by overbuilding; whereas the allowable settlement of structures such as control towers, etc., may be small in order to prevent overstressing the concrete or steel of which they are built, or because of the necessity for adhering to established grades. Therefore a soil may be entirely satisfactory for one type of construction but may require special treatment for other types. Strength and settlement characteristics of soils are dependent upon a number of variables, such as structure, in-place density, moisture content, cycles of loading in their geologic history, etc., which are not readily evaluated by a classification system such as used here. For these reasons only very general statements can be made as to the suitability of the various soil types as foundations; this is especially true for fine-grained soils. In general, the gravels and

for most construction purposes. If highly organic soils occur in the foundation, they may be removed if limited in extent, they may be displaced by dumping firmer soils on top, or piling may be driven through them to a stronger layer; proper treatment will depend upon the structure involved.

Graphical Presentation of Soils Data

11. It is customary to present the results of soils explorations on drawings or plans as schematic representations of the borings or test pits with the soils encountered shown by various symbols. Commonly used hatching symbols are small irregular round symbols for gravel, dots for sand, vertical lines for silts, and diagonal lines for clays. Combinations of these symbols represent various combinations of materials found in the explorations. This system has been adapted to the various soil groups in the unified soil classification system and the appropriate symbols are shown in column 4 of table A1. As an alternative to the hatching symbols, they may be omitted and the appropriate group letter symbol (CL, etc.) written in the boring log. In addition to the symbols on logs of borings, the effective size, D_{10} (grain size in mm corresponding to 10 per cent finer by weight), of coarse-grained soils and the natural water content of fine-grained soils should be shown by the side of the log. Other descriptive abbreviations may be used as deemed appropriate. In certain special instances the use of color to delineate soil types on maps and drawings is desirable. A suggested color scheme to show the major soil groups is described in column 5 of table A1.

A-12

Table A1

CHARACTERISTICS PERTINENT TO EMBANKMENTS AND FOUNDATIONS

Major Divisions (1)	(2)	Letter (3)	Symbol: Hatching (4)	Symbol: Color (5)	Name (6)	Value for Embankments (7)	Permeability Cm Per Sec (8)	Compaction Characteristics (9)	Std AASHO Max Unit Dry Weight Lb Per Cu Ft (10)	Value for Foundations (11)	Requirements for Seepage Control (12)
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW		Red	Well graded gravels or gravel sand mixtures, little or no fines	Very stable, pervious shells of dikes and dams	$k > 10^{-2}$	Good, tractor, rubber-tired, steel-wheeled roller	125-135	Good bearing value	Positive cutoff
		GP		Red	Poorly-graded gravels or gravel sand mixtures, little or no fines	Reasonably stable, pervious shells of dikes and dams	$k > 10^{2}$	Good, tractor, rubber-tired, steel-wheeled roller	115-125	Good bearing value	Positive cutoff
		GM		Yellow	Silty gravels, gravel sand-silt mixtures	Reasonably stable, not particularly suited to shells, but may be used for impervious cores or blankets	$k = 10^{3}$ to 10^{6}	Good, with close control, rubber-tired, sheepsfoot roller	120-135	Good bearing value	Toe trench to none
		GC		Yellow	Clayey gravels, gravel sand clay mixtures	Fairly stable, may be used for impervious core	$k = 10^{-6}$ to 10^{8}	Fair, rubber-tired, sheepsfoot roller	115-130	Good bearing value	None
	SAND AND SANDY SOILS	SW		Red	Well graded sands or gravelly sands, little or no fines	Very stable, pervious sections, slope protection required	$k > 10^{3}$	Good, tractor	110-130	Good bearing value	Upstream blanket and toe drainage or wells
		SP		Red	Poorly-graded sands or gravelly sands, little or no fines	Reasonably stable, may be used in dike section with flat slopes	$k > 10^{3}$	Good, tractor	100-120	Good to poor bearing value depending on density	Upstream blanket and toe drainage or wells
		SM		Yellow	Silty sands, sand-silt mixtures	Fairly stable, not particularly suited to shells, but may be used for impervious cores or dikes	$k = 10^{3}$ to 10^{6}	Good, with close control, rubber-tired, sheepsfoot roller	110 125	Good to poor bearing value depending on density	Upstream blanket and toe drainage or wells
		SC		Yellow	Clayey sands, sand-silt mixtures	Fairly stable, use for impervious core for flood control structures	$k = 10^{6}$ to 10^{-8}	Fair, sheepsfoot roller, rubber tired	105 125	Good to poor bearing value	None
FINE GRAINED SOILS	SILTS AND CLAYS LL < 50	ML		Green	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	Poor stability, may be used for embankments with proper control	$k = 10^{3}$ to 10^{6}	Good to poor, close control essential, rubber-tired roller, sheepsfoot roller	95 120	Very poor, susceptible to liquefaction	Toe trench to none
		CL		Green	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Stable, impervious cores and blankets	$k = 10^{6}$ to 10^{8}	Fair to good sheepsfoot roller, rubber tired	95 120	Good to poor bearing	None
		OL		Green	Organic silts and organic silt-clays of low plasticity	Not suitable for embankments	$k = 10^{4}$ to 10^{6}	Fair to poor, sheepsfoot roller	80 100	Fair to poor bearing may have excessive settlements	None
	SILTS AND CLAYS LL > 50	MH		Blue	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Poor stability, core of hydraulic fill dam, not desirable in rolled fill construction	$k = 10^{4}$ to 10^{6}	Poor to very poor, sheepsfoot roller	70 95	Poor bearing	None
		CH		Blue	Inorganic clays of high plasticity, fat clays	Fair stability with flat slopes, thin cores, blankets and dike sections	$k = 10^{6}$ to 10^{8}	Fair to poor, sheepsfoot roller	75-105	Fair to poor bearing	None
		OH		Blue	Organic clays of medium to high plasticity, organic silts	Not suitable for embankments	$k = 10^{6}$ to 10^{8}	Poor to very poor, sheepsfoot roller	65 100	Very poor bearing	None
HIGHLY ORGANIC SOILS		Pt		Orange	Peat and other highly organic soils	Not used for construction		Compaction not practical		Remove from foundations	

Notes: 1 Values in columns 7 and 11 are for guidance only Design should be based on test results
2 In column 9, the equipment listed will usually produce the desired densities with a reasonable number of passes when moisture conditions and thickness of lift are properly controlled
3 Column 10, unit dry weights are for compacted soil at optimum moisture content for Standard AASHO (Standard Proctor) compactive effort

R 112852-C

A-12

APPENDIX GT.1B

UNIFIED SOIL CLASSIFICATION SYSTEM

CHARACTERISTICS OF SOIL GROUPS

PERTAINING TO ROADS AND AIRFIELDS

UNIFIED SOIL CLASSIFICATION SYSTEM

APPENDIX B

CHARACTERISTICS OF SOIL GROUPS PERTAINING TO ROADS AND AIRFIELDS

Introduction

1. The properties desired in soils for foundations under roads and airfields and for base courses under flexible pavements are: adequate strength, good compaction characteristics, adequate drainage, resistance to frost action in areas where frost is a factor, and acceptable compression and expansion characteristics. Certain of these properties, if inadequate in the soils available, may be supplied by proper construction methods. For instance, materials having good drainage characteristics are desirable, but if such materials are not available locally, adequate drainage may be obtained by installing a properly designed water collecting system. Strength requirements for base course materials, to be used immediately under the pavement of a flexible pavement structure, are high and only good quality materials are acceptable. However, low strengths in subgrade materials may be compensated for in many cases by increasing the thickness of overlying concrete pavement or of base materials in flexible pavement construction. From the foregoing brief discussion, it may be seen that the proper design of roads and airfield pavements requires the evaluation of soil properties in more detail than is possible by use of the general soils classification system. However, the grouping of soils in the classification system is such that a general indication of their behavior in road and airfield construction may be obtained.

Features Shown on Soils Classification Sheet

2. General characteristics of the soil groups pertinent to roads and airfields are presented in table B1. Columns 1 through 5 show major

should be used in situations where this is a problem. The coarse-grained soils in general are the best subgrade, subbase, and base materials. The GW group has excellent qualities as a subgrade and subbase, and is good as base material. It is noted that the adjective "excellent" is not used for any of the soils for base courses; it is considered that the adjective "excellent" should be used in reference to a high quality processed crushed stone. Poorly-graded gravels and some silty gravels, groups GP and GMd, are usually only slightly less desirable as subgrade or subbase materials, and under favorable conditions may be used as base materials for certain conditions; however, poor gradation and other factors sometimes reduce the value of such soils to such extent that they offer only moderate strength and therefore their value as a base material is less. The GMu, GC, and SW groups are reasonably good subgrade materials, but are generally poor to not suitable as bases. The SP and SMd soils usually are considered fair to good subgrade and subbase materials but in general are poor to not suitable for base materials. The SMu and SC soils are fair to poor subgrade and subbase materials, and are not suitable for base materials. The fine-grained soils range from fair to very poor subgrade materials as follows: silts and lean clays (ML and CL), fair to poor; organic silts, lean organic clays, and micaceous or diatomaceous soils (OL and MH), poor; fat clays and fat organic clays (CH and OH), poor to very poor. These qualities are compensated for in flexible pavement design by increasing the thickness of overlying base material, and in rigid pavement design by increasing the pavement thickness or by the addition of a base course layer. None of the fine-grained soils are suitable as subbase or base materials. The fibrous organic soils (group Pt) are very poor subgrade materials and should be removed wherever possible, otherwise, special construction measures should be adopted. They are not suitable as subbase and base materials. The California Bearing Ratio (CBR) values shown in column 15 give a relative indication of the strength of the various soil groups as used in flexible pavement design. Similarly, values of subgrade modulus (k) in column 16 are relative indications of strengths from plate-bearing tests as used in rigid pavement design. As these tests are used for the design of pavements, actual water in the soil pores will help to diminish ice segregation in the subgrade and subbase.

Compressibility and expansion

7. These characteristics of soils may be of two types insofar as their applicability to road and runway design is concerned. The first is the relatively long-term compression or consolidation under the dead weight of the structure, and the second is the short-term compression and rebound under moving wheel loads. The long-term consolidation of soils becomes a factor in design primarily when heavy fills are made on compressible soils. If adequate provision is made for this type of settlement during construction it will have little influence on the load-carrying capacity of the pavement. However, when elastic soils subject to compression and rebound under wheel load are encountered, adequate protection must be provided, as even small movements of this type soil may be detrimental to the base and wearing course of pavements. It is fortunate that the free-draining, coarse-grained soils (GW, GP, SW, and SP), which in general make the best subgrade and subbase materials, exhibit almost no tendency toward high compressibility or expansion. In general, the compressibility of soils increases with increasing liquid limit. The foregoing is not completely true, as compressibility is also influenced by soil structure, grain shape, previous loading history, and other factors that are not evaluated in the classification system. Undesirable compressibility or expansion characteristics may be reduced by distribution of load through a greater thickness of overlying material. This, in general, is adequately handled by the CBR method of design for flexible pavements; however, rigid pavements may require the addition of an acceptable base course under the pavement.

Drainage characteristics

8. The drainage characteristics of soils are a direct reflection of their permeability. The evaluation of drainage characteristics for use in roads and runways is shown in column 12. The presence of moisture in base, subbase, and subgrade materials, except for free-draining, coarse-grained soils, may cause the development of pore water pressures and loss of strength. The moisture may come from infiltration of rain water or by

MIL-STD-621A. These values are included primarily for guidance, design or control of construction should be based on test results.

Graphical Presentation of Soils Data

10. It is customary to present the results of soils explorations on drawings as schematic representations of the borings or test pits or on soil profiles with the various soils encountered shown by appropriate symbols. As one approach, the group letter symbol (CL, etc.) may be written in the appropriate section of the log. As an alternative, hatching symbols shown in column 4 of table B1 may be used. In addition, the natural water content of fine-grained soils should be shown along the side of the log. Other descriptive abbreviations may be used as deemed appropriate. In certain special instances the use of color to delineate soil types on maps and drawings is desirable. A suggested color scheme to show the major soil groups is described in column 5 of table B1.

MIL-STD-621A. These values are included primarily for guidance, design or control of construction should be based on test results.

Graphical Presentation of Soils Data

10. It is customary to present the results of soils explorations on drawings as schematic representations of the borings or test pits or on soil profiles with the various soils encountered shown by appropriate symbols. As one approach, the group letter symbol (CL, etc.) may be written in the appropriate section of the log. As an alternative, hatching symbols shown in column 4 of table B1 may be used. In addition, the natural water content of fine-grained soils should be shown along the side of the log. Other descriptive abbreviations may be used as deemed appropriate. In certain special instances the use of color to delineate soil types on maps and drawings is desirable. A suggested color scheme to show the major soil groups is described in column 5 of table B1.

Standard Method for Particle-Size Analysis of Soils[1]

This standard is issued under the fixed designation D 422, the number immediately following the designation indicates the year of original adoption or in the case of revision, the year of last revision A number in parentheses indicates the year of last reapproval A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval

[ε1] NOTE—Section 2 was added editorially and subsequent sections renumbered in July 1984

1 Scope

1 1 This method covers the quantitative determination of the distribution of particle sizes in soils. The distribution of particle sizes larger than 75 μm (retained on the No 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 75 μm is determined by a sedimentation process, using a hydrometer to secure the necessary data (Notes 1 and 2)

NOTE 1—Separation may be made on the No 4 (4 75-mm), No 40 (425-μm), or No 200 (75-μm) sieve instead of the No 10 For whatever sieve used, the size shall be indicated in the report.

NOTE 2—Two types of dispersion devices are provided. (*1*) a high-speed mechanical stirrer, and (*2*) air dispersion Extensive investigations indicate that air-dispersion devices produce a more positive dispersion of plastic soils below the 20-μm size and appreciably less degradation on all sizes when used with sandy soils. Because of the definite advantages favoring air dispersion, its use is recommended. The results from the two types of devices differ in magnitude, depending upon soil type, leading to marked differences in particle size distribution, especially for sizes finer than 20 μm.

2. Referenced Documents

2.1 *ASTM Standards*

D 421 Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[2]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[3]

E 100 Specification for ASTM Hydrometers[4]

3. Apparatus

3 1 *Balances*—A balance sensitive to 0 01 g for weighing the material passing a No 10 (2.00-mm) sieve, and a balance sensitive to 0 1 % of the mass of the sample to be weighed for weighing the material retained on a No 10 sieve.

3.2 *Stirring Apparatus*—Either apparatus A or B may be used.

3 2 1 Apparatus A shall consist of a mechanically operated stirring device in which a suitably mounted electric motor turns a vertical shaft at a speed of not less than 10 000 rpm without load The shaft shall be equipped with a replaceable stirring paddle made of metal plastic, or hard rubber, as shown in Fig. 1 The shaft shall be of such length that the stirring paddle will operate not less than ¾ in (19 0 mm) nor more than 1½ in. (38 1 mm) above the bottom of the dispersion cup A special dispersion cup conforming to either of the designs shown in Fig. 2 shall be provided to hold the sample while it is being dispersed

3 2 2 Apparatus B shall consist of an air-jet dispersion cup[5] (Note 3) conforming to the general details shown in Fig. 3 (Notes 4 and 5)

NOTE 3—The amount of air required by an air-jet dispersion cup is of the order of 2 ft^3/min, some small air compressors are not capable of supplying sufficient air to operate a cup

NOTE 4—Another air-type dispersion device, known as a dispersion tube, developed by Chu and Davidson at Iowa State College, has been shown to give results equivalent to those secured by the air-jet dispersion cups. When it is used, soaking of the sample can be done in the sedimentation cylinder, thus eliminating the need for transferring the slurry When the air-dispersion tube is used, it shall be so indicated in the report.

NOTE 5—Water may condense in air lines when not in use. This water must be removed, either by using a water trap on the air line, or by blowing the water out of the line before using any of the air for dispersion purposes.

3 3 *Hydrometer*—An ASTM hydrometer, graduated to read in either specific gravity of the suspension or grams per litre of suspension, and conforming to the requirements for hydrometers 151H or 152H in Specifications E 100. Dimensions of both hydrometers are the same, the scale being the only item of difference.

3 4 *Sedimentation Cylinder*—A glass cylinder essentially 18 in (457 mm) in height and 2½ in (63 5 mm) in diameter, and marked for a volume of 1000 mL. The inside diameter shall be such that the 1000-mL mark is 36 ± 2 cm from the bottom on the inside

3 5 *Thermometer*—A thermometer accurate to 1°F (0 5°C)

3 6 *Sieves*—A series of sieves of square-mesh woven-wire cloth conforming to the requirements of Specification E 11 A full set of sieves includes the following (Note 6)

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18 03 on Texture Plasticity and Density Characteristics of Soils.

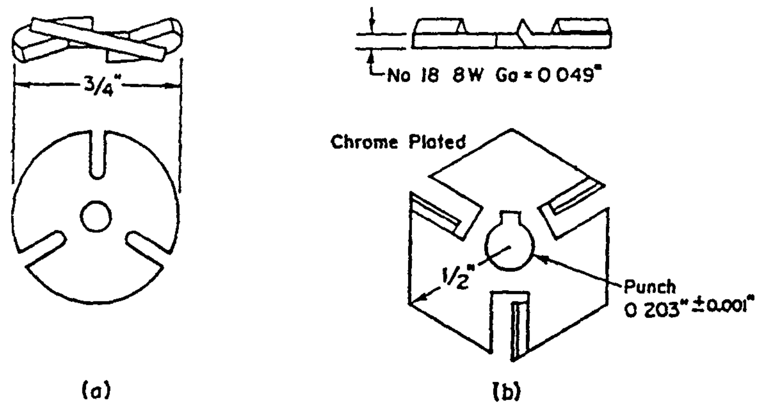
Current edition approved Nov 21 1963 Originally published 1935 Replaces D 422 – 62.

[2] *Annual Book of ASTM Standards* Vol 04 08

[3] *Annual Book of ASTM Standards* Vol 14 02

[4] *Annual Book of ASTM Standards* Vol 14 01

[5] Detailed working drawings for this cup are available at a nominal cost from the American Society for Testing and Materials, 1916 Race St Philadelphia, PA 19103 Order Adjunct No 12-404220-00



Metric Equivalents

in	0 001	0 049	0.203	½	¾
mm	0 03	1.24	5 16	12 7	19 0

FIG. 1 Detail of Stirring Paddles

3-in. (75-mm)	No 10 (2 00-mm)
2-in (50-mm)	No 20 (850-µm)
1½-in. (37 5-mm)	No 40 (425-µm)
1-in. (25 0-mm)	No 60 (250-µm)
¾-in (19 0-mm)	No 140 (106-µm)
⅜-in. (9 5-mm)	No. 200 (75-µm)
No. 4 (4 75-mm)	

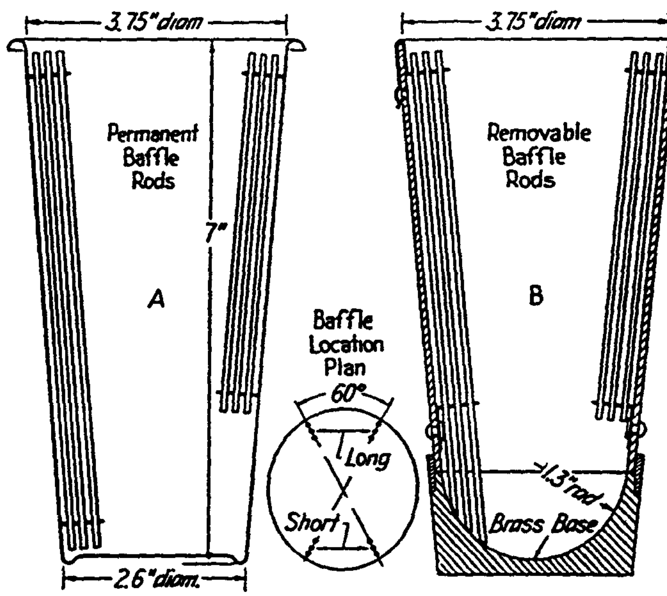
NOTE 6—A set of sieves giving uniform spacing of points for the graph, as required in Section 17, may be used if desired. This set consists of the following sieves:

3-in. (75-mm)	No 16 (1 18-mm)
1½-in. (37.5-mm)	No. 30 (600-µm)
¾-in. (19.0-mm)	No. 50 (300-µm)
⅜-in. (9.5-mm)	No 100 (150-µm)
No. 4 (4 75-mm)	No 200 (75-µm)
No. 8 (2.36-mm)	

3 7 *Water Bath or Constant-Temperature Room*—A water bath or constant-temperature room for maintaining the soil suspension at a constant temperature during the hydrometer analysis. A satisfactory water tank is an insulated tank that maintains the temperature of the suspension at a convenient constant temperature at or near 68°F (20°C). Such a device is illustrated in Fig. 4 In cases where the work is performed in a room at an automatically controlled constant temperature, the water bath is not necessary.

3.8 *Beaker*—A beaker of 250-mL capacity

3 9 *Timing Device*—A watch or clock with a second hand



Metric Equivalents

in.	1.3	2.6	3 75
mm	33	66	95.2

FIG 2 Dispersion Cups of Apparatus

4. Dispersing Agent

4 1 A solution of sodium hexametaphosphate (sometimes called sodium metaphosphate) shall be used in distilled or demineralized water, at the rate of 40 g of sodium hexametaphosphate/litre of solution (Note 7)

NOTE 7—Solutions of this salt, if acidic slowly revert or hydrolyze back to the orthophosphate form with a resultant decrease in dispersive action Solutions should be prepared frequently (at least once a month) or adjusted to pH of 8 or 9 by means of sodium carbonate. Bottles containing solutions should have the date of preparation marked on them

4 2 All water used shall be either distilled or demineralized water The water for a hydrometer test shall be brought to the temperature that is expected to prevail during the hydrometer test. For example, if the sedimentation cylinder is to be placed in the water bath, the distilled or demineralized water to be used shall be brought to the temperature of the controlled water bath, or, if the sedimentation cylinder is used in a room with controlled temperature, the water for the test shall be at the temperature of the room The basic temperature for the hydrometer test is 68°F (20°C) Small variations of temperature do not introduce differences that are of practical significance and do not prevent the use of corrections derived as prescribed

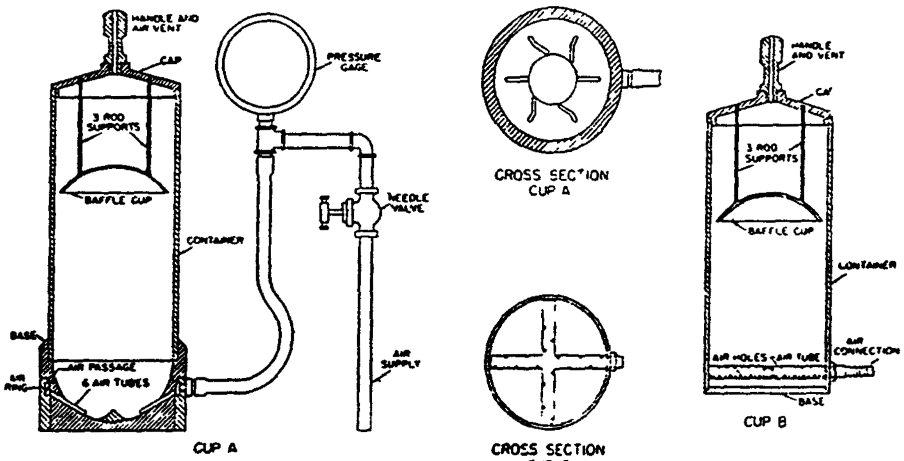


FIG. 3 Air-Jet Dispersion Cups of Apparatus B

5 Test Sample

5 1 Prepare the test sample for mechanical analysis as outlined in Practice D 421 During the preparation procedure the sample is divided into two portions. One portion contains only particles retained on the No. 10 (2.00-mm) sieve while the other portion contains only particles passing the No 10 sieve The mass of air-dried soil selected for purpose of tests, as prescribed in Practice D 421, shall be sufficient to yield quantities for mechanical analysis as follows:

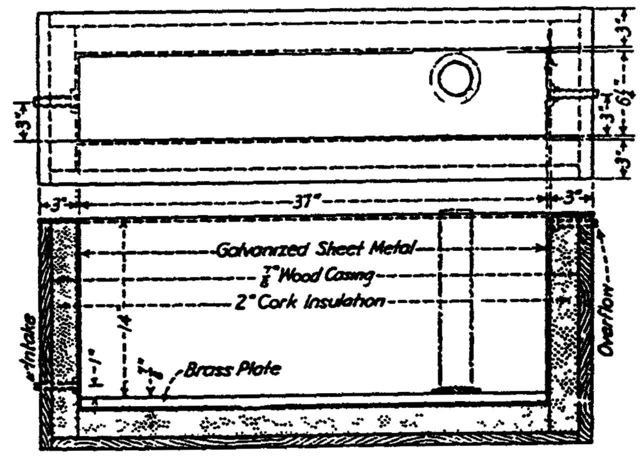
5 1.1 The size of the portion retained on the No. 10 sieve shall depend on the maximum size of particle, according to the following schedule:

Nominal Diameter of Largest Particles, in. (mm)	Approximate Minimum Mass of Portion, g
⅜ (9 5)	500
¾ (19 0)	1000
1 (25 4)	2000
1½ (38 1)	3000
2 (50 8)	4000
3 (76.2)	5000

5 1 2 The size of the portion passing the No. 10 sieve shall be approximately 115 g for sandy soils and approximately 65 g for silt and clay soils.

5 2 Provision is made in Section 5 of Practice D 421 for weighing of the air-dry soil selected for purpose of tests, the separation of the soil on the No 10 sieve by dry-sieving and washing, and the weighing of the washed and dried fraction retained on the No 10 sieve From these two masses the percentages retained and passing the No 10 sieve can be calculated in accordance with 12.1

NOTE 8—A check on the mass values and the thoroughness of pulverization of the clods may be secured by weighing the portion passing the No 10 sieve and adding this value to the mass of the washed and oven-dried portion retained on the No 10 sieve



	Metric Equivalents					
in.	⅞	1	3	6¼	14	37
mm	22.2	25 4	76.2	158.2	356	940

FIG. 4 Insulated Water Bath

SIEVE ANALYSIS OF PORTION RETAINED ON NO 10 (2.00-mm) SIEVE

6 Procedure

6 1 Separate the portion retained on the No 10 (2 00-mm) sieve into a series of fractions using the 3-in (75-mm) 2-in. (50-mm), 1½-in. (37 5-mm), 1-in. (25 0-mm), ¾-in. (19.0-mm), ⅜-in (9 5-mm), No 4 (4 75-mm), and No 10 sieves, or as many as may be needed depending on the sample or upon the specifications for the material under test.

6 2 Conduct the sieving operation by means of a lateral and vertical motion of the sieve, accompanied by a jarring action in order to keep the sample moving continuously over the surface of the sieve In no case turn or manipulate fragments in the sample through the sieve by hand Continue sieving until not more than 1 mass % of the residue on a sieve passes that sieve during 1 min of sieving When mechanical sieving is used test the thoroughness of sieving by using the hand method of sieving as described above

6 3 Determine the mass of each fraction on a balance conforming to the requirements of 3 1 At the end of weighing, the sum of the masses retained on all the sieves used should equal closely the original mass of the quantity sieved

HYDROMETER AND SIEVE ANALYSIS OF PORTION PASSING THE NO. 10 (2.00-mm) SIEVE

7. Determination of Composite Correction for Hydrometer Reading

7.1 Equations for percentages of soil remaining in suspension, as given in 14.3 are based on the use of distilled or demineralized water. A dispersing agent is used in the water, however, and the specific gravity of the resulting liquid is appreciably greater than that of distilled or demineralized water.

7.1.1 Both soil hydrometers are calibrated at 68°F (20°C), and variations in temperature from this standard temperature produce inaccuracies in the actual hydrometer readings. The amount of the inaccuracy increases as the variation from the standard temperature increases.

7.1.2 Hydrometers are graduated by the manufacturer to be read at the bottom of the meniscus formed by the liquid on the stem. Since it is not possible to secure readings of soil suspensions at the bottom of the meniscus, readings must be taken at the top and a correction applied.

7.1.3 The net amount of the corrections for the three items enumerated is designated as the composite correction, and may be determined experimentally.

7.2 For convenience, a graph or table of composite corrections for a series of 1° temperature differences for the range of expected test temperatures may be prepared and used as needed. Measurement of the composite corrections may be made at two temperatures spanning the range of expected test temperatures, and corrections for the intermediate temperatures calculated assuming a straight-line relationship between the two observed values.

7.3 Prepare 1000 mL of liquid composed of distilled or demineralized water and dispersing agent in the same proportion as will prevail in the sedimentation (hydrometer) test. Place the liquid in a sedimentation cylinder and the cylinder in the constant-temperature water bath, set for one of the two temperatures to be used. When the temperature of the liquid becomes constant, insert the hydrometer, and, after a short interval to permit the hydrometer to come to the temperature of the liquid, read the hydrometer at the top of the meniscus formed on the stem. For hydrometer 151H the composite correction is the difference between this reading and one; for hydrometer 152H it is the difference between the reading and zero. Bring the liquid and the hydrometer to the other temperature to be used, and secure the composite correction as before.

8. Hygroscopic Moisture

8.1 When the sample is weighed for the hydrometer test, weigh out an auxiliary portion of from 10 to 15 g in a small metal or glass container, dry the sample to a constant mass in an oven at 230 ± 9°F (110 ± 5°C), and weigh again. Record the masses.

9. Dispersion of Soil Sample

9.1 When the soil is mostly of the clay and silt sizes, weigh out a sample of air-dry soil of approximately 50 g. When the soil is mostly sand the sample should be approximately 100 g.

9.2 Place the sample in the 250-mL beaker and cover with 125 mL of sodium hexametaphosphate solution (40 g/L). Stir until the soil is thoroughly wetted. Allow to soak for at least 16 h.

9.3 At the end of the soaking period, disperse the sample further, using either stirring apparatus A or B. If stirring apparatus A is used, transfer the soil - water slurry from the beaker into the special dispersion cup shown in Fig. 2, washing any residue from the beaker into the cup with distilled or demineralized water (Note 9). Add distilled or demineralized water, if necessary, so that the cup is more than half full. Stir for a period of 1 min.

NOTE 9—A large size syringe is a convenient device for handling the water in the washing operation. Other devices include the wash-water bottle and a hose with nozzle connected to a pressurized distilled water tank.

9.4 If stirring apparatus B (Fig. 3) is used, remove the cover cap and connect the cup to a compressed air supply by means of a rubber hose. A air gage must be on the line between the cup and the control valve. Open the control valve so that the gage indicates 1 psi (7 kPa) pressure (Note 10). Transfer the soil - water slurry from the beaker to the air-jet dispersion cup by washing with distilled or demineralized water. Add distilled or demineralized water, if necessary, so that the total volume in the cup is 250 mL, but no more.

NOTE 10—The initial air pressure of 1 psi is required to prevent the soil - water mixture from entering the air-jet chamber when the mixture is transferred to the dispersion cup.

9.5 Place the cover cap on the cup and open the air control valve until the gage pressure is 20 psi (140 kPa). Disperse the soil according to the following schedule:

Plasticity Index	Dispersion Period, min
Under 5	5
6 to 20	10
Over 20	15

Soils containing large percentages of mica need be dispersed for only 1 min. After the dispersion period, reduce the gage pressure to 1 psi preparatory to transfer of soil - water slurry to the sedimentation cylinder.

10. Hydrometer Test

10.1 Immediately after dispersion, transfer the soil - water slurry to the glass sedimentation cylinder, and add distilled or demineralized water until the total volume is 1000 mL.

10.2 Using the palm of the hand over the open end of the cylinder (or a rubber stopper in the open end), turn the cylinder upside down and back for a period of 1 min to complete the agitation of the slurry (Note 11). At the end of 1 min set the cylinder in a convenient location and take hydrometer readings at the following intervals of time (measured from the beginning of sedimentation), or as many as may be needed, depending on the sample or the specification for the material under test: 2, 5, 15, 30, 60, 250, and 1440 min. If the controlled water bath is used, the sedimentation cylinder should be placed in the bath between the 2- and 5-min readings.

NOTE 11—The number of turns during this minute should be approximately 60, counting the turn upside down and back as two turns.

Any soil remaining in the bottom of the cylinder during the first few turns should be loosened by vigorous shaking of the cylinder while it is in the inverted position

10.3 When it is desired to take a hydrometer reading, carefully insert the hydrometer about 20 to 25 s before the reading is due to approximately the depth it will have when the reading is taken. As soon as the reading is taken, carefully remove the hydrometer and place it with a spinning motion in a graduate of clean distilled or demineralized water.

NOTE 12—It is important to remove the hydrometer immediately after each reading. Readings shall be taken at the top of the meniscus formed by the suspension around the stem since it is not possible to secure readings at the bottom of the meniscus.

10.4 After each reading, take the temperature of the suspension by inserting the thermometer into the suspension.

11. Sieve Analysis

11.1 After taking the final hydrometer reading, transfer the suspension to a No. 200 (75-µm) sieve and wash with tap water until the wash water is clear. Transfer the material on the No. 200 sieve to a suitable container, dry in an oven at 230 ± 9°F (110 ± 5°C) and make a sieve analysis of the portion retained, using as many sieves as desired, or required for the material, or upon the specification of the material under test.

CALCULATIONS AND REPORT

12. Sieve Analysis Values for the Portion Coarser than the No. 10 (2.00-mm) Sieve

12.1 Calculate the percentage passing the No. 10 sieve by dividing the mass passing the No. 10 sieve by the mass of soil originally split on the No. 10 sieve, and multiplying the result by 100. To obtain the mass passing the No. 10 sieve, subtract the mass retained on the No. 10 sieve from the original mass.

12.2 To secure the total mass of soil passing the No. 4 (4.75-mm) sieve, add to the mass of the material passing the No. 10 sieve the mass of the fraction passing the No. 4 sieve and retained on the No. 10 sieve. To secure the total mass of soil passing the ⅜-in. (9.5-mm) sieve, add to the total mass of soil passing the No. 4 sieve, the mass of the fraction passing the ⅜-in. sieve and retained on the No. 4 sieve. For the remaining sieves, continue the calculations in the same manner.

12.3 To determine the total percentage passing for each sieve, divide the total mass passing (see 12.2) by the total mass of sample and multiply the result by 100.

13. Hygroscopic Moisture Correction Factor

13.1 The hydroscopic moisture correction factor is the ratio between the mass of the oven-dried sample and the air-dry mass before drying. It is a number less than one, except when there is no hygroscopic moisture.

14. Percentages of Soil in Suspension

14.1 Calculate the oven-dry mass of soil used in the hydrometer analysis by multiplying the air-dry mass by the hygroscopic moisture correction factor.

TABLE 1 Values of Correction Factor a for Different Specific Gravities of Soil Particles[A]

Specific Gravity	Correction Factor[A]
2.95	0.94
2.90	0.95
2.85	0.96
2.80	0.97
2.75	0.98
2.70	0.99
2.65	1.00
2.60	1.01
2.55	1.02
2.50	1.03
2.45	1.05

[A] For use in equation for percentage of soil remaining in suspension when using Hydrometer 152H.

14.2 Calculate the mass of a total sample represented by the mass of soil used in the hydrometer test, by dividing the oven-dry mass used by the percentage passing the No. 10 (2.00-mm) sieve, and multiplying the result by 100. This value is the weight W in the equation for percentage remaining in suspension.

14.3 The percentage of soil remaining in suspension at the level at which the hydrometer is measuring the density of the suspension may be calculated as follows (Note 13): For hydrometer 151H:

$$P = [(100\,000/W) \times G/(G - G_1)](R - G_1)$$

NOTE 13—The bracketed portion of the equation for hydrometer 151H is constant for a series of readings and may be calculated first and then multiplied by the portion in the parentheses.

For hydrometer 152H:

$$P = (Ra/W) \times 100$$

where:

a = correction faction to be applied to the reading of hydrometer 152H. (Values shown on the scale are computed using a specific gravity of 2.65. Correction factors are given in Table 1),

P = percentage of soil remaining in suspension at the level at which the hydrometer measures the density of the suspension,

R = hydrometer reading with composite correction applied (Section 7),

W = oven-dry mass of soil in a total test sample represented by mass of soil dispersed (see 14.2), g,

G = specific gravity of the soil particles, and

G_1 = specific gravity of the liquid in which soil particles are suspended. Use numerical value of one in both instances in the equation. In the first instance any possible variation produces no significant effect, and in the second instance, the composite correction for R is based on a value of one for G_1.

15. Diameter of Soil Particles

15.1 The diameter of a particle corresponding to the percentage indicated by a given hydrometer reading shall be calculated according to Stokes' law (Note 14), on the basis that a particle of this diameter was at the surface of the suspension at the beginning of sedimentation and had settled to the level at which the hydrometer is measuring the density of the suspension. According to Stokes' law:

$$D = \sqrt{[30n/980(G - G_1)] \times L/T}$$

where

D = diameter of particle mm.,
η = coefficient of viscosity of the suspending medium (in this case water) in poises (varies with changes in temperature of the suspending medium),
L = distance from the surface of the suspension to the level at which the density of the suspension is being measured, cm. (For a given hydrometer and sedimentation cylinder, values vary according to the hydrometer readings. This distance is known as effective depth (Table 2)),
T = interval of time from beginning of sedimentation to the taking of the reading, min.
G = specific gravity of soil particles, and
G_1 = specific gravity (relative density) of suspending medium (value may be used as 1.000 for all practical purposes)

NOTE 14—Since Stokes law considers the terminal velocity of a single sphere falling in an infinity of liquid, the sizes calculated represent the diameter of spheres that would fall at the same rate as the soil particles.

15.2 For convenience in calculations the above equation may be written as follows.

$$D = K\sqrt{L/T}$$

where:

K = constant depending on the temperature of the suspension and the specific gravity of the soil particles. Values of K for a range of temperatures and specific gravities are given in Table 3. The value of K does not change for a series of readings constituting a test, while values of L and T do vary.

15.3 Values of D may be computed with sufficient accuracy, using an ordinary 10-in. slide rule.

NOTE 15—The value of L is divided by T using the A- and B-scales, the square root being indicated on the D-scale. Without ascertaining the value of the square root it may be multiplied by K, using either the C- or CI-scale.

16. Sieve Analysis Values for Portion Finer than No. 10 (2.00-mm) Sieve

16.1 Calculation of percentages passing the various sieves used in sieving the portion of the sample from the hydrometer test involves several steps. The first step is to calculate the mass of the fraction that would have been retained on the No. 10 sieve had it not been removed. This mass is equal to the total percentage retained on the No. 10 sieve (100 minus total percentage passing) times the mass of the total sample represented by the mass of soil used (as calculated in 14.2), and the result divided by 100.

16.2 Calculate next the total mass passing the No 200 sieve. Add together the fractional masses retained on all the sieves, including the No 10 sieve, and subtract this sum from the mass of the total sample (as calculated in 14.2).

16.3 Calculate next the total masses passing each of the other sieves in a manner similar to that given in 12.2.

16.4 Calculate last the total percentages passing by dividing the total mass passing (as calculated in 16.3) by the total mass of sample (as calculated in 14.2), and multiply the result by 100

TABLE 2 Values of Effective Depth Based on Hydrometer and Sedimentation Cylinder of Specified Sizes[A]

Hydrometer 151H		Hydrometer 152H			
Actual Hydrometer Reading	Effective Depth, L, cm	Actual Hydrometer Reading	Effective Depth, L, cm	Actual Hydrometer Reading	Effective Depth, L, cm
1.000	16.3	0	16.3	31	11.2
1.001	16.0	1	16.1	32	11.1
1.002	15.8	2	16.0	33	10.9
1.003	15.5	3	15.8	34	10.7
1.004	15.2	4	15.6	35	10.6
1.005	15.0	5	15.5		
1.006	14.7	6	15.3	36	10.4
1.007	14.4	7	15.2	37	10.2
1.008	14.2	8	15.0	38	10.1
1.009	13.9	9	14.8	39	9.9
1.010	13.7	10	14.7	40	9.7
1.011	13.4	11	14.5	41	9.6
1.012	13.1	12	14.3	42	9.4
1.013	12.9	13	14.2	43	9.2
1.014	12.6	14	14.0	44	9.1
1.015	12.3	15	13.8	45	8.9
1.016	12.1	16	13.7	46	8.8
1.017	11.8	17	13.5	47	8.6
1.018	11.5	18	13.3	48	8.4
1.019	11.3	19	13.2	49	8.3
1.020	11.0	20	13.0	50	8.1
1.021	10.7	21	12.9	51	7.9
1.022	10.5	22	12.7	52	7.8
1.023	10.2	23	12.5	53	7.6
1.024	10.0	24	12.4	54	7.4
1.025	9.7	25	12.2	55	7.3
1.026	9.4	26	12.0	56	7.1
1.027	9.2	27	11.9	57	7.0
1.028	8.9	28	11.7	58	6.8
1.029	8.6	29	11.5	59	6.6
1.030	8.4	30	11.4	60	6.5
1.031	8.1				
1.032	7.8				
1.033	7.6				
1.034	7.3				
1.035	7.0				
1.036	6.8				
1.037	6.5				
1.038	6.2				

[A] Values of effective depth are calculated from the equation:

$$L = L_1 + \tfrac{1}{2}\left[L_2 - (V_B/A)\right]$$

where:

L = effective depth, cm,
L_1 = distance along the stem of the hydrometer from the top of the bulb to the mark for a hydrometer reading, cm,
L_2 = overall length of the hydrometer bulb, cm,
V_B = volume of hydrometer bulb, cm³ and
A = cross-sectional area of sedimentation cylinder cm²

Values used in calculating the values in Table 2 are as follows:

For both hydrometers, 151H and 152H:
L_2 = 14.0 cm
V_B = 67.0 cm³
A = 27.8 cm²

For hydrometer 151H:
L_1 = 10.5 cm for a reading of 1.000
= 2.3 cm for a reading of 1.031

For hydrometer 152H:
L_1 = 10.5 cm for a reading of 0 g/litre
= 2.3 cm for a reading of 50 g/litre

17. Graph

17.1 When the hydrometer analysis is performed, a graph

TABLE 3 Values of K for Use in Equation for Computing Diameter of Particle in Hydrometer Analysis

Temperature °C	Specific Gravity of Soil Particles								
	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
16	0.01510	0.01505	0.01481	0.01457	0.01435	0.01414	0.01394	0.01374	0.01356
17	0.01511	0.01486	0.01462	0.01439	0.01417	0.01396	0.01376	0.01356	0.01338
18	0.01492	0.01467	0.01443	0.01421	0.01399	0.01378	0.01359	0.01339	0.01321
19	0.01474	0.01449	0.01425	0.01403	0.01382	0.01361	0.01342	0.1323	0.01305
20	0.01456	0.01431	0.01408	0.01386	0.01365	0.01344	0.01325	0.01307	0.01289
21	0.01438	0.01414	0.01391	0.01369	0.01348	0.01328	0.01309	0.01291	0.01273
22	0.01421	0.01397	0.01374	0.01353	0.01332	0.01312	0.01294	0.01276	0.01258
23	0.01404	0.01381	0.01358	0.01337	0.01317	0.01297	0.01279	0.01261	0.01243
24	0.01388	0.01365	0.01342	0.01321	0.01301	0.01282	0.01264	0.01246	0.01229
25	0.01372	0.01349	0.01327	0.01306	0.01286	0.01267	0.01249	0.01232	0.01215
26	0.01357	0.01334	0.01312	0.01291	0.01272	0.01253	0.01235	0.01218	0.01201
27	0.01342	0.01319	0.01297	0.01277	0.01258	0.01239	0.01221	0.01204	0.01188
28	0.01327	0.01304	0.01283	0.01264	0.01244	0.01255	0.01208	0.01191	0.01175
29	0.01312	0.01290	0.01269	0.01249	0.01230	0.01212	0.01195	0.01178	0.01162
30	0.01298	0.01276	0.01256	0.01236	0.01217	0.01199	0.01182	0.01165	0.01149

of the test results shall be made, plotting the diameters of the particles on a logarithmic scale as the abscissa and the percentages smaller than the corresponding diameters to an arithmetic scale as the ordinate. When the hydrometer analysis is not made on a portion of the soil, the preparation of the graph is optional since values may be secured directly from tabulated data.

18. Report

18.1 The report shall include the following:

18.1.1 Maximum size of particles,

18.1.2 Percentage passing (or retained on) each sieve, which may be tabulated or presented by plotting on a graph (Note 16),

18.1.3 Description of sand and gravel particles:

18.1.3.1 Shape—rounded or angular,

18.1.3.2 Hardness—hard and durable, soft, or weathered and friable,

18.1.4 Specific gravity, if unusually high or low,

18.1.5 Any difficulty in dispersing the fraction passing the No. 10 (2.00-mm) sieve, indicating any change in type and amount of dispersing agent, and

18.1.6 The dispersion device used and the length of the dispersion period.

NOTE 16—This tabulation of graph represents the gradation of the sample tested. If particles larger than those contained in the sample were removed before testing, the report shall so state giving the amount and maximum size.

18.2 For materials tested for compliance with definite specifications, the fractions called for in such specifications shall be reported. The fractions smaller than the No. 10 sieve shall be read from the graph.

18.3 For materials for which compliance with definite specifications is not indicated and when the soil is composed almost entirely of particles passing the No. 4 (4.75-mm) sieve, the results read from the graph may be reported as follows:

(1) Gravel, passing 3-in. and retained on No. 4 sieve %
(2) Sand, passing No. 4 sieve and retained on No. 200 sieve %
  (a) Coarse sand, passing No. 4 sieve and retained on No. 10 sieve %
  (b) Medium sand, passing No. 10 sieve and retained on No. 40 sieve %
  (c) Fine sand, passing No. 40 sieve and retained on No. 200 sieve %
(3) Silt size, 0.074 to 0.005 mm %
(4) Clay size, smaller than 0.005 mm %
  Colloids, smaller than 0.001 mm %

18.4 For materials for which compliance with definite specifications is not indicated and when the soil contains material retained on the No. 4 sieve sufficient to require a sieve analysis on that portion, the results may be reported as follows (Note 17):

SIEVE ANALYSIS

Sieve Size	Percentage Passing
3-in.	
2-in.	
1½-in.	
1-in.	
¾-in.	
⅜-in.	
No. 4 (4.75-mm)	
No. 10 (2.00-mm)	
No. 40 (425-μm)	
No. 200 (75-μm)	

HYDROMETER ANALYSIS

0.074 mm	
0.005 mm	
0.001 mm	

NOTE 17—No. 8 (2.36-mm) and No. 50 (300-μm) sieves may be substituted for No. 10 and No. 40 sieves.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

Character

Major Divisions (1)	(2)	Symbol Letter (3)	Symbol Hatching (4)	Symbol Color (5)	Name (6)	Value as Subgrade When Not Subject to Frost Action (7)	Value as S. When Not S to Frost A (8)
COARSE-GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW		Red	Well-graded gravels or gravel-sand mixtures, little or no fines	Excellent	Excellent
		GP		Red	Poorly graded gravels or gravel-sand mixtures, little or no fines	Good to excellent	Good
		GM d		Yellow	Silty gravels gravel-sand-silt mixtures	Good to excellent	Good
		GM u		Yellow		Good	Fair
		GC		Yellow	Clayey gravels, gravel-sand-clay mixtures	Good	Fair
	SAND AND SANDY SOILS	SW		Red	Well-graded sands or gravelly sands, little or no fines	Good	Fair to goc
		SP		Red	Poorly graded sands or gravelly sands, little or no fines	Fair to good	Fair
		SM d		Yellow	Silty sands, sand-silt mixtures	Fair to good	Fair to goc
		SM u		Yellow		Fair	Poor to fa
		SC		Yellow	Clayey sands, sand-clay mixtures	Poor to fair	Poor
FINE-GRAINED SOILS	SILTS AND CLAYS LL IS LESS THAN 50	ML		Green	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	Poor to fair	Not suitab.
		CL		Green	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Poor to fair	Not suitab
		OL		Green	Organic silts and organic silt-clays of low plasticity	Poor	Not suitab
	SILTS AND CLAYS LL IS GREATER THAN 50	MH		Blue	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Poor	Not suitab.
		CH		Blue	Inorganic clays of high plasticity, fat clays	Poor to fair	Not suitab.
		OH		Blue	Organic clays of medium to high plasticity, organic silts	Poor to very poor	Not suitab
HIGHLY ORGANIC SOILS		Pt		Orange	Peat and other highly organic soils	Not suitable	Not suitab

Note

1 Column 3, division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is on basis of plasticity index is 5 or less the suffix u will be used otherwise

2 In column 13, the equipment listed will usually produce the required densities with a reasonable number of passes when moisture condi are listed because variable soil characteristics within a given soil group may require different equipment In some instances a com

a Processed base materials and other angular material. Steel-wheeled and rubber-tired rollers are recommended for hard angular m subject to degradation

b Finishing Rubber-tired equipment is recommended for rolling during final shaping operations for most soils and processed mate

c Equipment size The following sizes of equipment are necessary to assure the high densities required for airfield construction

Crawler-type tractor -- total weight in excess of 30 000 lb

Rubber-tired equipment -- wheel load in excess of 15 000 lb wheel loads as high as 40 000 lb may be necessary to obtain the re

Sheepsfoot roller -- unit pressure (on 6- to 12-sq-in foot) to be in excess of 250 psi and unit pressures as high as 650 psi m be at least 5 per cent of the total peripheral area of the drum using the diameter measured to the faces of the feet

3 Column 14 unit dry weights are for compacted soil at optimum moisture content for modified AASHO compaction effort (CE 55)

4 In column 15 the maximum value that can be used in design of airfields is, in some cases limited by gradation and plasticity requ

B-8-A

Table [illegible]

Characteristics Pertinent to Roads and Airfields

	Value as Subgrade When Not Subject to Frost Action (7)	Value as Subbase When Not Subject to Frost Action (8)	Value as Base When Not Subject to Frost Action (9)	Potential Frost Action (10)	Compressibility and Expansion (11)	Drainage Characteristics (12)	
and	Excellent	Excellent	Good	None to very slight	Almost none	Excellent	Crawle roller
-sand	Good to excellent	Good	Fair to good	None to very slight	Almost none	Excellent	Crawle roller
mixtures	Good to excellent	Good	Fair to good	Slight to medium	Very slight	Fair to poor	Rubber roller
	Good	Fair	Poor to not suitable	Slight to medium	Slight	Poor to practically impervious	Rubber roller
y mixtures	Good	Fair	Poor to not suitable	Slight to medium	Slight	Poor to practically impervious	Rubber roller
ands,	Good	Fair to good	Poor	None to very slight	Almost none	Excellent	Crawle rolle
	Fair to good	Fair	Poor to not suitable	None to very slight	Almost none	Excellent	Crawle roller
	Fair to good	Fair to good	Poor	Slight to high	Very slight	Fair to poor	Rubber roller moistu
	Fair	Poor to fair	Not suitable	Slight to high	Slight to medium	Poor to practically impervious	Rubber roller
-s	Poor to fair	Poor	Not suitable	Slight to high	Slight to medium	Poor to practically impervious	Rubber roller
ands, rock ds or city	Poor to fair	Not suitable	Not suitable	Medium to very high	Slight to medium	Fair to poor	Rubber roller
m plastic- s, silty	Poor to fair	Not suitable	Not suitable	Medium to high	Medium	Practically impervious	Rubber roller
clays of	Poor	Not suitable	Not suitable	Medium to high	Medium to high	Poor	Rubber roller
liatomaceous stic silts	Poor	Not suitable	Not suitable	Medium to very high	High	Fair to poor	Sheeps roller
ity, fat	Poor to fair	Not suitable	Not suitable	Medium	High	Practically impervious	Sheeps roller
s	Poor to very poor	Not suitable	Not suitable	Medium	High	Practically impervious	Sheeps roller
soils	Not suitable	Not suitable	Not suitable	Slight	Very high	Fair to poor	Compac

and airfields only Subdivision is on basis of Atterberg limits suffix d (e g GMd) will be used when the liquid lim[illegible] 25 or less and th

reasonable number of passes when moisture conditions and thickness of lift are properly controlled In some instances several types of equip[illegible]
different equipment In some instances, a combination of two types may be necessary
red rollers are recommended for hard angular materials with limited fines or screenings Rubber-tired equipment is recommended for softer mat[illegible]

operations for most soils and processed materials
densities required for airfield construction

as 40 000 lb may be necessary to obtain the required densities for some materials (based on contact pressure of approximately 65 to 150 psi)
250 psi and unit pressures as high as 650 psi may be necessary to obtain the required densities for some materials The area of the feet shoul[illegible]
meter measured to the faces of the feet
ified AASHO compaction effort (CE 55)
ses, limited by gradation and plasticity requirements

B-8-B

d Airfields

Potential Frost Action (10)	Compressibility and Expansion (11)	Drainage Characteristics (12)	Compaction Equipment (13)	Unit Dry Weight lb per cu ft (14)	Typical Design Values CBR (15)	Subgrade Modulus k lb per cu in (16)
None to very slight	Almost none	Excellent	Crawler-type tractor, rubber-tired roller steel-wheeled roller	125-140	40-80	300-500
None to very slight	Almost none	Excellent	Crawler-type tractor, rubber-tired roller steel-wheeled roller	110-140	30-60	300-500
Slight to medium	Very slight	Fair to poor	Rubber-tired roller, sheepsfoot roller close control of moisture	125-145	40-60	300-500
Slight to medium	Slight	Poor to practically impervious	Rubber-tired roller, sheepsfoot roller	115-135	20-30	200-500
Slight to medium	Slight	Poor to practically impervious	Rubber-tired roller, sheepsfoot roller	130-145	20-40	200-500
None to very slight	Almost none	Excellent	Crawler-type tractor, rubber-tired roller	110-130	20-40	200-400
None to very slight	Almost none	Excellent	Crawler-type tractor, rubber-tired roller	105-135	10-40	150-400
Slight to high	Very slight	Fair to poor	Rubber-tired roller sheepsfoot roller, close control of moisture	120-135	15-40	150-400
Slight to high	Slight to medium	Poor to practically impervious	Rubber-tired roller, sheepsfoot roller	100-130	10-20	100-300
Slight to high	Slight to medium	Poor to practically impervious	Rubber-tired roller, sheepsfoot roller	100-135	5-20	100-300
Medium to very high	Slight to medium	Fair to poor	Rubber-tired roller, sheepsfoot roller close control of moisture	90-130	15 or less	100-200
Medium to high	Medium	Practically impervious	Rubber-tired roller, sheepsfoot roller	90-130	15 or less	50-150
Medium to high	Medium to high	Poor	Rubber-tired roller, sheepsfoot roller	90-105	5 or less	50-100
Medium to very high	High	Fair to poor	Sheepsfoot roller, rubber-tired roller	80-105	10 or less	50-100
Medium	High	Practically impervious	Sheepsfoot roller, rubber-tired roller	90-115	15 or less	50-150
Medium	High	Practically impervious	Sheepsfoot roller, rubber-tired roller	80-110	5 or less	25-100
Slight	Very high	Fair to poor	Compaction not practical	-	-	-

033159A

(e g , GMd) will be used when the liquid limit is 25 or less and the

re properly controlled In some instances several types of equipment necessary
r screenings Rubber-tired equipment is recommended for so er mater als

rs (based on contact pressure of approximately [illegible] psi)
required densities for some materials The area of the fee could

6-8-a

EG&G ROCKY FLATS PLANT	Manual:	5-21200-OPS
EMAD MANUAL OPERATION SOP	Procedure No.	GT.2, Rev. 1
	Page:	1 of 14
	Effective Date:	June 10, 1991
Category 2	Organization:	Environmental Management

TITLE
DRILLING AND SAMPLING USING
HOLLOW STEM AUGER TECHNIQUES

Approved By:

_____________________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes procedures that will be used at the Rocky Flats Plant (RFP) for drilling and obtaining samples of soil and rock from hollow-stem auger borings In general, hollow-stem auger coring will be the preferred technique for obtaining environmental samples of subsoil and bedrock from boreholes at the RFP Other types of samples may also be obtained from hollow-stem auger borings This SOP describes hollow-stem auger drilling and sampling equipment and procedures, and decontamination that will be used for field data collection and documentation in order to attain acceptable standards of accuracy, precision, comparability, representativeness, and completeness.

3.0 PERSONNEL QUALIFICATIONS

Personnel overseeing drilling operations and logging alluvial and bedrock materials should be geologists with a minimum of a B S or B.A degree in geology and have applicable field experience. Other qualified personnel may include geotechnical engineers or field technicians with an appropriate amount of field experience or on-the-job training under supervision of another qualified person. The personnel will be trained to log according to the RFP "reference" cores and samples (see SOP GT 1, Logging Alluvial and Bedrock Material)

4.0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure:

A Compendium of Superfund Field Operations Methods EPA/540/P-87/001 December 1987

Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA Interim Final EPA/540/G-89/004 October 1988

RCRA Facility Investigation Guidance Interim Final May 1989

RCRA Groundwater Monitoring Technical Enforcement Guidance Document EPA, OSWER-9950.1, September, 1986.

4.2 INTERNAL REFERENCES

Related SOPs cross-referenced by this SOP are

- SOP FO.3, General Equipment Decontamination
- SOP FO.4, Heavy Equipment Decontamination
- SOP FO.8, Handling of Drilling Fluids and Cuttings
- SOP FO 9, Handling of Residual Samples
- SOP GT 1, Logging Alluvial and Bedrock Material
- SOP GT.3, Isolating Bedrock from Alluvium with Grouted Surface Casing
- SOP GT 4, Rotary Drilling and Rock Coring
- SOP GT.5, Plugging and Abandonment of Boreholes
- SOP GT 6, Monitoring Well and Piezometer Installation
- SOP GT 10, Borehole Clearing

5.0 PROCEDURES FOR DRILLING AND SAMPLING

Hollow-stem augers are one type of continuous-flight auger used for advancing boreholes when discrete samples of the subsurface materials are obtained They are particularly applicable for sampling materials with a tendency to cave in and for environmental sampling The augers consist of sections of steel tubing (usually 5 feet long) with steel helical flights around the outside Segments of auger are added as the borehole advances, and samples are retrieved through the inside of the auger without having to remove the auger from the borehole during sampling

With this technique, samples will be obtained either with standard split spoon or California drive samplers, or with a continuous core augering technique The continuous coring technique can obtain up to 5-foot-long cores in a 5-foot-long sample barrel, however, at the RFP sampling will be conducted in increments of 2 feet to enhance sample recovery unless otherwise specified in the FSP Drive sampling will normally obtain a 12- to 18-inch-long sample depending on the length of the sampler Visual logging of the alluvial and bedrock materials will be performed according to SOP GT 1, Logging of Alluvial and Bedrock Material Sampling for chemical analysis is addressed in this SOP All sampling equipment will be protected from the ground surface with clear plastic sheeting. All drilling and sampling activities will be conducted in accordance with the project Health and Safety Plan

5.1 EQUIPMENT AND MATERIALS

The following equipment and materials are needed for hollow-stem auger drilling and soil sampling. Only the types of samplers required by the sampling specified in the Field Sampling Plan (FSP) will be required on a given project

- Drill rig equipped for drilling and sampling with hollow-stem augers

- Continuous core augering equipment (including 2-1/2- to 3-inch inside diameter sample barrel suitable for 2-foot sample rods)

- Standard split spoon sampler (ASTM D 1586)

- California spoon sampler
- Brass (or stainless steel) California liners (2-inch-diameter)
- 3-inch-long stainless steel volatile/semi-volatile organic analysis (VOA) sample liner for continuous auger core barrel
- Teflon® film (cut in 4-inch x 4-inch squares)
- Plastic caps for California and VOA liners
- Self-adhesive labels
- Ice chests (sample shuttles)
- High-pressure steamer/sprayer
- Long-handled bristle brushes
- Wash/rinse tubs
- Phosphate-free lab-grade detergent (e.g., Liquinox)
- Location map
- Weighted tape measure
- Water level probe

- Distilled water
- Drums for containment of cuttings
- Appropriate health and safety equipment
- Field book
- Boring log forms

5.2 DRILLING PROCEDURES

Boreholes will be drilled by using hollow-stem augers and the sampling equipment required by the FSP. All drilling equipment, including the rig, water tanks, augers, drill rods, samplers, etc., will be decontaminated before arrival at the work area site Between boreholes, all down-hole equipment will decontaminated, and sampling equipment will be decontaminated between samples. Equipment will be inspected for evidence of fuel oil or hydraulic system leaks (See SOP FO.3, General Equipment Decontamination, and SOP FO 4, Heavy Equipment Decontamination). If lubricants are required for down-hole equipment, only pure vegetable oil will be used

Before drilling, borings will have been located, numbered, and identified using stakes or spray paint on paved surfaces Buried metal objects will have been located by using geophysical methods, and utility clearance will have been accomplished according to SOP GT 10, Borehole Clearing

After boreholes have been cleared and obstructions removed, an exclusion zone will be established according to the project Health and Safety Plan, and the drill rig will be set up. The boring will be advanced to the depth indicated and sampled according to the FSP

For borings where environmental samples will be obtained in the bedrock, the borehole will be drilled into the top of the weathered bedrock prior to installation of a casing according to SOP GT 3, Isolating Bedrock From Alluvium With Grouted Surface Casing The bottom of the surface casing will be embedded below the weathered bedrock surface in soil borings according to SOP GT 3 The embedment may vary for monitoring wells according to the FSP or SOPAs After installing the casing, the bedrock will be drilled and sampled by using hollow-stem augers small enough to fit through the casing in boreholes designated for environmental sampling In boreholes that are drilled only for geologic logging, hydraulic or geotechnical testing, or monitoring wells, the portion of the borehole below the casing may be drilled using conventional rotary or rock coring techniques (SOP GT 4, Rotary Drilling and Rock Coring) This will normally allow for the use of a smaller diameter surface casing.

It is anticipated that most or all of the weathered bedrock can be drilled and sampled by using the continuous hollow-stem auger coring method However, if bedrock that is sufficiently cemented to render this method ineffective is encountered in borings designated for environmental sampling, the cemented zone will be rock cored using filtered air as the drilling medium according to SOP GT.4, Rotary Drilling and Rock Coring. After the cemented zone is penetrated, the boring will continue with hollow-stem auger coring. If necessary, this may require reaming the cored section with air-rotary techniques

The borings will be logged lithologically by examination and classification of the samples Documentation will be completed by the site geologist according to Section 8 0 of this SOP SOP GT 1, Logging Alluvial and Bedrock Material, describes procedures for material classification and borehole logging

At the first indication of free water on the sampler or in samples, the time and estimated depth will be recorded However, it is frequently difficult to determine the true water level in hollow-stem auger borings at the time of drilling, particularly when drilling in low-permeability soil or bedrock

Therefore, water levels will also be measured after drilling In low-permeability deposits, it is possible for a borehole to be drilled below the groundwater level and not collect water for several hours or even days It is therefore important to note moisture changes in the samples when evaluating groundwater conditions at the time of drilling. During the drilling and while the augers are being removed, the cuttings and unsaved portions of samples from the boring will be containerized according to SOP FO 8, Handling of Drilling Fluids and Cuttings, and SOP FO 9, Handling of Residual Samples

5.3 SAMPLING PROCEDURES

5.3.1 Continuous Core Auger Sampling

The continuous coring method advances a split barrel that is contained within the lead auger The augers rotate around the sampler and cut while the sample barrel is prevented from rotating Continuous core samples are collected in the barrel. The barrel will be unlined except for a 3-inch long stainless steel VOA sample liner placed at the bottom end of the barrel directly behind the cutting shoe Once the core barrel has been removed from the borehole, opened, scanned, and measured, the VOA sample liner will immediately be capped with Teflon®-lined plastic caps, sealed with electrical tape, labeled, and placed in a cooler with ice In order to obtain a composite sample for additional analyses, including semi-VOAs, the sampler will be closed and placed in a safe location, out of the direct sun, until three consecutive 2-foot samples have been obtained Once the three consecutive samples have been obtained, the core barrels will be opened and each sample will then be classified, logged, peeled, composited, and placed in appropriate containers for analytical testing according to SOP FO 13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples. Sample intervals and requirements for compositing are defined in the FSP or SOPA

Sample peeling will involve discarding the portion of sample that was in direct contact with the sampler Once the samples have been peeled, a linear scraping of the peeled samples will be placed in a stainless steel bowl and mixed with a stainless steel instrument Soil particles (gravels) larger than the jar mouth will be discarded Peeling and compositing will be conducted with separate decontaminated stainless steel instruments

Samples for geotechnical testing will consist of approximately 3/4-filled pint-sized glass jars with air-tight lids placed in compartmented shipping cartons designed to prevent breakage of the jars. Sample peeling is not required for geotechnical samples

5.3.2 Drive Sampling

Drive samples will be obtained in general accordance with ASTM Designation D 1586 After drilling to the predetermined depth, the standard split spoon or California sampler will be attached to the end of the drill rod and lowered to the bottom of the boring. The standard 140-pound hammer assembly will then be attached to the top of the drill rod. The depth to the bottom of the sampler will be recorded, and reference marks at 6-inch increments will be placed on the drill rod The test consists of driving the sampler with the standard 140-pound hammer dropped 30 inches

When using the 2-inch-outside-diameter (O.D) standard split spoon sampler, drive the sampler through three 6-inch increments (or 100 blows, whichever occurs first), with the sum of the last two increments being the Standard Penetration Count or Blow Count or N-value, and the first 6-inch increment being considered as seating

A California barrel with brass (or stainless steel) liners may be substituted for the standard split barrel The integrity of the sample can generally be better maintained since thin-walled liners containing the sample can be removed from the barrel and sealed Since the California sampler is shorter than the standard split spoon sampler, it will be driven only 12 inches, with blow counts recorded for each 6-inch increment However, several blows are required before marking and counting blows to seat the sampler

A California barrel has a 2.5-inch O D and a 2-inch inside diameter (I D) Modified California samplers with larger diameters are also available The liners for a conventional California barrel have a 1 94-inch I D Although not precisely equivalent, the blow count obtained by using a 2-inch I.D California barrel is frequently considered to be comparable to the N-value obtained using a standard barrel Blow counts using larger samplers will not be equivalent, and larger hammers may be required to drive them under some conditions

A rope and cathead arrangement is generally used to obtain drive samples Automatic trip hammers are sometimes used If a rope and cathead arrangement is used, excessive turns of the rope on the cathead must be avoided, since they will result in friction and drag between the rope and cathead Two turns of the rope on the cathead will be used and sufficient slack in the rope provided during hammer freefall to prevent excessive friction.

Standard split spoon samples saved for geotechnical testing will consist of 3/4-filled pint-sized glass jars with airtight lids placed in compartmented shipping cartons designed to prevent breakage of the jars Samples for VOA analytical testing will be obtained by placing a 3-inch long stainless steel VOA sample liner at the bottom end of the barrel directly behind the cutting shoe Composite samples for additional analyses, including semi-VOAs, will consist of linear scrapes from three consecutive peeled samples (see Subsection 5.3 1) placed in containers described in SOP FO 13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples For California liner samples, the geotechnical samples may be saved in the liners with plastic end caps

5.3.3 VOC Sampling

- VOC samples will be collected from the base of every other 2-foot drive sample from the ground surface to the water table

- A VOC sample will be collected in the bottom of the first drive sample below the water table

- A final VOC sample will be collected from the base of the first drive within bedrock immediately below the alluvial material

- Additional VOC samples will be collected as follows

  - If a lithologic feature or HNu reading indicates the possibility that anomalous VOC contamination exists, then a sample will be taken at the base of the next drive interval

  - If the sampler is opened, scanned and a color change, free product, or other physical evidence indicating the possibility for contamination is observed in a location other than where a pretargeted VOC sample is located, a 3" section will be immediately cut, pulled, wrapped, placed in a wide mouth jar and sealed The sample will be sent to the lab for subcoring and analysis.

5.4 BORING COMPLETION AND ABANDONMENT

After the borehole has been advanced to its final depth, it will either be abandoned or completed as a monitoring well (see SOP GT.5, Plugging and Abandonment of Boreholes, and SOP GT 6, Monitoring Well and Piezometer Installation)

The boring location stake will be left in the ground adjacent to the borehole, and a board or other cover placed over the hole until it has been grouted All boreholes to be abandoned with a depth greater than 1 foot will be grouted the same day that abandonment is completed The boring location stake will then be placed in the grout

6.0 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

Quality Assurance (QA) and Quality Control (QC) activities will be accomplished according to applicable project plans as well as quality requirements presented in this SOP

QA samples for soils fall into five categories

- Duplicate
- Matrix spike
- Matrix spike duplicate
- Equipment rinsate
- Field blank

SOP FO 13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples describes the general handling of samples Applicable project plans specify QA sample frequencies

Sample collection procedures will be the same as those described in Section 5 0 for duplicate, matrix spike, and duplicate matrix spike samples These samples are intended to be as close to exact replicates of the original samples as possible They are obtained immediately adjacent to the planned samples that they are intended to duplicate

A rinsate sample from sampling equipment is intended to check for potential contamination of the sample by the sampling equipment For the soil sampling operation, a rinsate sample will be collected from sampling equipment with any liners in place before the sampling equipment is used Approximately 3 liters of distilled water will be rinsed over a decontaminated sampler and collected in a large decontaminated stainless steel bowl A decontaminated glass beaker will be used to dip the water from the bowl and fill the sample bottles The rinsate samples will be analyzed for the same parameters as the soil samples

Field blank samples are containers filled with clean water that are handled and moved the same as the other samples to check for potential cross-contamination resulting from field handling and movement procedures

7.0 DECONTAMINATION

Generalized equipment decontamination procedures will include·

- Sampling equipment. Decontamination will be conducted between individual sampling points to minimize potential cross-contamination. Sampling equipment will be decontaminated according to SOP FO.3, General Equipment Decontamination During drilling and sampling, decontaminated equipment will be placed on new plastic or racks until it is used At least two sets of samplers will be available so that one set can be used while the other is being decontaminated

- Drilling equipment Decontamination of augers, drill stems, drill bits, and other down-hole equipment will be conducted after each boring is complete Drill rigs will be decontaminated when moved out of a work area or when they become unusually dirty as a result of site or drilling conditions, at the discretion of the site or project manager Decontamination of drilling equipment is described in more detail in SOP FO 4, Heavy Equipment Decontamination

8.0 DOCUMENTATION

All information required by this SOP will be documented on the Borehole Log Form (in SOP GT 1, Logging Alluvial and Bedrock Materials) and the Hollow-Stem Auger Drilling Field Activities Report Form, Form GT 2A The Field Activities Report Form will be filled out for each day of drilling at a given borehole location and, in situations where more than one boring is drilled and completed per day per drill rig, at least one form will be completed per boring. The borehole log will include information on subsurface material classification and lithology The Field Activities Report will include the following information and have space for comments and documentation of general observations

- Project, crew, drilling contractor and borehole identifications
- Date
- Weather
- Equipment descriptions (rig, bits, etc)
- Water level
- Depth to bedrock
- Borehole depth and diameter
- Decontamination
- Waste types, volumes and drums used
- End-of-day status (i e , partially complete, abandonment, etc.)
- Chronological record of activities

HOLLOW STEM AUGER DRILLING
FIELD ACTIVITIES REPORT

PROJECT NUMBER ______________________________ DATE ______________

PROJECT NAME ______________________________

BOREHOLE IDENTIFICATION ______________________________

WEATHER CONDITIONS ______________________________

RIG TYPE ______________________________

DRILLING COMPANY/DRILLER ______________________________

GEOLOGIST/ENGINEER ______________________________

CREW MEMBERS ______________________________

WATER LEVEL/TIME ______________________________

TOTAL DEPTH ______________________________

DECONTAMINATION ______________________________

WASTE TYPES, VOLUMES
AND DRUMS USED ______________________________

____

____

DIAMETER OF BORING ______________________________

TYPE AND SIZE OF AUGERS
AND BIT ______________________________

SAMPLING TYPES, DEPTHS ______________________________

____

____

HAMMER SIZE ______________________________

DEPTH TO BEDROCK ______________________________

END-OF-DAY STATUS ______________________________

CHRONOLOGICAL RECORD
OF ACTIVITIES ______________________________

____

____

____

COMMENTS ______________________________

____

____

EG&G ROCKY FLATS PLANT	Manual:	5-21200-OPS
EMAD MANUAL OPERATION SOP	Procedure No.:	GT.4, Rev. 1
	Page:	1 of 10
	Effective Date:	June 10, 1991
Category 2	Organization:	Environmental Management

TITLE
ROTARY DRILLING AND ROCK CORING

Approved

______________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes procedures that will be used at the Rocky Flats Plant (RFP) for rotary drilling and rock coring, using air and water as drilling media It addresses equipment, field procedures, decontamination, and documentation, that will be used for rotary drilling and rock coring, and describes documentation of these procedures in order to attain acceptable standards of accuracy, precision, comparability, representativeness, and completeness

3.0 PERSONNEL QUALIFICATIONS

Personnel overseeing the plugging and abandonment at boreholes will be geologists, geotechnical engineers, or field technicians with an appropriate amount of applicable field experience or on-the-job training under supervision of another qualified person.

4.0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure

A Compendium of Superfund Field Operations Methods. EPA/540/P-87/001 December 1987.

Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA Interim Final October 1988

RCRA Facility Investigation Guidance Interim Final May 1989

RCRA Ground-Water Monitoring Technical Enforcement Guidance Document. EPA, OSWER-9950 1 Washington D C September, 1986

4.2 INTERNAL REFERENCES

Related SOPs cross-referenced in this SOP are as follows

- SOP GT 2, Drilling and Sampling Using Hollow-Stem Auger Techniques
- SOP FO 4, Heavy Equipment Decontamination
- SOP GT 10, Borehole Clearing
- SOP FO.3, General Equipment Decontamination
- SOP FO.8, Handling of Drilling Fluids and Cuttings
- SOP GT 1, Logging Alluvial and Bedrock Material
- SOP GT 6, Monitoring Well and Piezometer Installation
- SOP GT.3, Isolating Bedrock from the Alluvium with Grouted Surface Casing
- SOP GT.5, Plugging and Abandonment of Boreholes

5.0 EQUIPMENT AND PROCEDURES

5.1 GENERAL

Rotary drilling and coring methods that use air or water as the drilling media are common techniques employed to obtain stratigraphic, lithologic, hydrogeologic, geotechnical, and environmental data, as well as a means for monitoring well installation In general, hollow-stem continuous-flight augers will be the preferred technique for drilling boreholes to collect environmental samples of soil and rock (see SOP GT.2, Drilling and Sampling Using Hollow-Stem Auger Techniques) The use of air or water can alter analytical chemistry or physical property test results by altering sample moisture, or by volatilizing contaminants (in case of air) or by washing them away (in the case of water) Using water when drilling can also alter the groundwater chemistry in the vicinity of the borehole, and needs to be accounted for during development of wells Rotary drilling and rock coring may be used for advancing boreholes with or without environmental sampling in zones of hard material which cannot be penetrated with augers

Samples obtained for analytical chemistry testing will be prepared and contained in general accordance with SOP GT 2, Drilling and Sampling Using Hollow-Stem Auger Techniques In general, air will be the drilling medium used when it is necessary to penetrate cemented zones of rock in auger borings drilled for environmental sampling. Water will typically be used as the drilling medium when drilling relatively deep bedrock wells and when obtaining rock core exclusively for geologic logging. Alternatively, dual-tube air percussion or ODEX drilling methods using water or air may be appropriate for some conditions. The appropriate work plan or a standard operating procedure addendum (SOPA) will outline drilling requirements for each project.

5.2 EQUIPMENT AND MATERIALS

5.2.1 General Rotary Drilling Equipment

The following is a list of equipment and materials for rotary drilling

- Drill rig with appropriately sized drill bits and rods
- Portable recirculation tanks for water rotary
- Preapproved water for water rotary
- Conveyance equipment (pumps and hoses)
- Air compressor with appropriate air filter(s)
- High pressure steamer/sprayer
- Wash/rinse tubs
- Weighted tape measure

- Phosphate-free, lab grade detergent (e g , Liquinox)
- Water level probe
- Appropriate health and safety equipment
- Drums for containment of cuttings and fluids (SOP FO 8, Handling of Drilling Fluids and Cuttings)
- Boring log form
- Field activities report form
- Pint-sized plastic bottles with screw caps for cuttings (SOP GT 1, Logging Alluvial and Bedrock Material)

5.2.2 Supplemental Equipment for Rock Coring

Additional equipment for rock coring will consist of the following:

- Core barrel assembly
- Wire line or core rods
- Coring log forms
- Core boxes with wooden blocks
- Measuring tape
- Camera (photography is security controlled at Rocky Flats Plant)
- Core barrel rack
- Plastic wrap for core
- Marking pen, black, permanent

5.3 PROCEDURES

Boreholes will be drilled using a rig equipped with rotary drilling equipment capable of advancing the borehole to the depth specified in the Field Sampling Plan (FSP) All drilling equipment, including the rig, water transportation tanks, bits, and drill rods, will be decontaminated according to SOP FO 4, Heavy Equipment Decontamination and SOP FO 3, General Equipment Decontamination These decontamination procedures will also be followed between boreholes for downhole equipment and between work areas of different contaminant characterization for the drilling rig Drilling equipment will be inspected to ensure that hydraulic system and fuel leaks do not introduce organic contamination on site or into the borehole Any leaks that may introduce such contamination will be repaired before drilling. Only pure vegetable oil products may be used to lubricate downhole drilling and sampling equipment

Borehole locations will be cleared before drilling, according to SOP GT 10, Borehole Clearing. Drill cuttings and fluids will be handled according to SOP FO.8, Handling of Drilling Fluids and Cuttings Boreholes will be abandoned according to SOP GT.5, Plugging and Abandonment of Boreholes All procedures will be conducted according to the applicable Health and Safety Plan Project-specific requirements will be addressed in a SOPA

5.3.1 Rotary Drilling Techniques

Conventional rotary drilling involves the introduction of a drilling medium (fluid) into the borehole through the drill rods and circulation of the medium back up the hole to remove drill cuttings The hole is advanced by the cutting action of a rotating drill bit at the bottom of the hole Reverse circulation methods are similar to conventional rotary methods, except that the drilling medium is injected down the annulus between an inner and outer double casing and returns back up the inside of the inner casing. Some reverse circulation methods use rotary techniques, some use non-rotating percussion techniques, and some use a combination of the two Samples of cuttings obtained when rotary drilling to be saved for geotechnical testing or future geologic reference will be placed in pint-sized plastic jars with screw-on tops and saved in core boxes

5.3.1.1 Water

Water used for rotary drilling will consist of RFP potable water Water transportation tanks and conveyance equipment will be contaminant-free and dedicated for the use with preapproved water to ensure that the preapproved water introduced into the borehole is also contaminant-free Portable decontaminated water recirculation tanks will be used for rotary operations Excavated sumps or pits (lined or unlined) will not be used Decontamination of tanks and conveyance equipment will also be conducted in accordance with SOP FO.3, General Equipment Decontamination and/or SOP FO 4, Heavy Equipment Decontamination

5.3.1.2 Air

Conventional air compressors used for air rotary methods contain oil for lubricating moving parts and compress air and oil in their operation To avoid introducing contaminants into the borehole, a filtration system designed to provide oil-free air and approved by EG&G will be used Depending on the requirements of the particular project, such a system may consist of an air-cooled aftercooler, a regenerative dryer, a coalescing filter, and a particulate afterfilter, all arranged in series The particular filtration system design will depend on the compressor equipment, the project requirements, and anticipated ambient conditions The filtration system will be matched appropriately to the compressor's capacity so that the reduction in the flow of air to the drilling equipment is tolerable The filtration system components will be changed or monitored according to the requirements of the design during operation and a record of this kept on the field activities report form (see Section 7, Documentation)

Dust control measures may also be required according to the Field Operations Plan (FOP) and Health and Safety Plan (HSP) The airborne dispersion of cuttings can be controlled to some extent by circulating the return air through a vortex or cyclone

5.3.2 Rock Coring

Continuous core samples collected using rock coring methods can be used to obtain relatively undisturbed samples of rock for stratigraphic, lithologic, hydrogeologic, and environmental data Conventional rock coring methods use a diamond coring bit instead of a conventional tricone or granular rotary bit

Continuous core samples will be extracted from the core barrel, placed on core racks, and logged by a geologist according to SOP GT 1, Logging Alluvial and Bedrock Material Rock core to be saved for geotechnical testing or further geologic observations will be placed in plastic core wrap and then placed in core boxes with appropriately sized dividers to protect and preserve the orientation of the core during movement and storage Coring equipment will also be decontaminated according to SOP FO.3, General Equipment Decontamination

Air or water drilling media used for coring must be contaminant-free Therefore, the provisions required in Subsections 5.3 1 1 and 5.3 1.2 for drilling fluids also apply to rock coring procedures.

6.0 DECONTAMINATION

Generalized equipment decontamination procedures will include

- <u>Sampling equipment</u> Decontamination will be conducted between individual sampling points to minimize potential cross-contamination Sampling equipment will be decontaminated according to SOP FO.3, General Equipment Decontamination During drilling and sampling, decontaminated equipment will be placed on new plastic sheeting or racks until it is used At least two sets of samplers will be available so that one set can be used while the other is being decontaminated

- Drilling equipment Decontamination (augers, drill stems, drill bits, and other downhole equipment) will be conducted after each boring is complete The drill rig will be decontaminated when moved to a new work area that has a different contaminant characterization Decontamination of drilling equipment is described in SOP FO 4, Heavy Equipment Decontamination

7.0 DOCUMENTATION

All information required by this SOP will be documented on the Borehole Log Form (in SOP GT 1 Logging Alluvial and Bedrock Materials) and the Rotary/Core Drilling Field Activities Report Form, Form GT 4 The Field Activities Report Form will be filled out for each day of drilling at a given borehole location and, in situations where more than one boring is drilled and completed per day per drill rig, at least one form will be completed per boring. The borehole log will include information on subsurface material classification and lithology Information on core length, core loss, percent of recovery; core breakage due to discontinuities, total core breakage; and rock classification and lithology will be recorded on the log form The Field Activities Report will include the following information and have space for comments and documentation of general observations.

- Project, and borehole identifications
- Weather
- Equipment conditions descriptions (rig, bits, etc)
- Personnel
- Drilling fluid used
- Drilling fluid return/loss and pressures
- Sampling information
- Waste disposal information
- Water level

- Borehole information
- Compressor/pump type
- End-of-day status (i e , partially complete, abandoned, etc)
- Log check list (for each core run)
- Chronological record of activities

ROTARY/CORE DRILLING FIELD ACTIVITIES REPORT

PROJECT NUMBER ______________________ DATE ____________________

PROJECT NAME ____

BOREHOLE IDENTIFICATION ____

COORDINATES _______________North________East________________

WEATHER CONDITIONS ____

RIG TYPE ____

DRILLING COMPANY/DRILLER ____

GEOLOGIST/ENGINEER ____

CREW MEMBERS ____

WATER LEVEL/TIME ____

TOTAL DEPTH ____

WASTE TYPES, VOLUMES AND DRUMS USED ____

____

____

DIAMETER OF BORING ____

TYPE AND SIZE OF BIT ____

SAMPLING TYPES AND DEPTHS ____

____

____

SIZE AND TYPE OF CASING ____

CASING HAMMER SIZE ____

DRILLING FLUID TYPE ____

FLUID RETURN/LOSS AND PRESSURES ____

____

____

COMPRESSOR/PUMP TYPE ____

DEPTH TO BEDROCK ____

END-OF-DAY STATUS ____

____

____

LOG CHECK LIST (FOR EACH RUN)

CORE LENGTHS	Y ______	N ______
CORE LOSS	Y ______	N ______
PERCENT RECOVERY	Y ______	N ______
CORE BREAKAGE DUE TO DISCONTINUITIES	Y ______	N ______
TOTAL CORE BREAKAGE	Y ______	N ______
ROCK CLASSIFICATION AND LITHOLOGY	Y ______	N ______

CHRONOLOGICAL RECORD OF ACTIVITIES ____

____

____

____

COMMENTS ____

____

____

____

____

EG&G ROCKY FLATS PLANT	Manual:	5-21200-OPS
EMAD MANUAL OPERATION SOP	Procedure No.:	GT 6, Rev. 1
	Page:	1 of 18
	Effective Date:	June 10, 1991
Category 2	Organization:	Environmental Management

TITLE
MONITORING WELLS AND
PIEZOMETER INSTALLATION

Approved By

_____________________________ / /
(Name of Approver) (Date)

1 0 TABLE OF CONTENTS

LIST OF FIGURES

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes procedures that will be used at the Rocky Flats Plant (RFP) for installing monitoring wells and open-pipe piezometers This SOP describes the equipment for drilling, field procedures, well material specifications, and decontamination procedures that will be used to install and document monitoring wells in order to attain acceptable standards of accuracy, precision, comparability, representativeness, and completeness

3.0 PERSONNEL QUALIFICATIONS

Personnel overseeing the installation of monitoring wells and piezometers will be geologists, geotechnical engineers, or field technicians with an appropriate amount of applicable field experience or on-the-job training under the supervision of another qualified person

4.0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure

A Compendium of Superfund Field Operations Methods EPA/540/P-87/001 December 1987.

Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA Interim Final. EPA/540/G-89/004 October 1988

RCRA Facility Investigation Guidance Interim Final May 1989

RCRA Groundwater Monitoring Technical Enforcement Guidance Document EPA, OSWER-9950 1, Washington D C , September, 1986

4.2 INTERNAL REFERENCES

Related SOPs cross-referenced in this SOP are as follows

- SOP FO 15, Use of PIDs and FIDs
- SOP FO 16, Field Radiological Measurements
- SOP FO 3, General Equipment Decontamination
- SOP FO 4, Heavy Equipment Decontamination
- SOP GT 1, Logging Alluvial and Bedrock Material
- SOP GT 2, Drilling and Sampling Using Hollow-stem Auger Techniques
- SOP GT 3, Isolating Bedrock from the Alluvium with Grouted Surface Casing
- SOP GT 4, Rotary Drilling and Rock Coring
- SOP FO 8, Handling of Drilling Fluids and Cuttings

5.0 EQUIPMENT AND PROCEDURES FOR MONITORING WELL AND PIEZOMETER INSTALLATION

Groundwater monitoring wells and open-pipe piezometers (observation wells) will be constructed in boreholes drilled and logged according to SOP GT 2, Drilling and Sampling Using Hollow-Stem Auger Techniques, or SOP GT 4, Rotary Drilling and Rock Coring, and SOP GT 1, Logging Alluvial and Bedrock Material The construction of monitoring wells is the same as that used for piezometers The distinction between wells and piezometers is based on the intended use Wells are used for obtaining samples of groundwater while piezometers are intended only for water level measurements If different types of piezometers are required (e g , isolated electronic or pneumatic piezometers), they will be addressed in another SOP or in a standard operating procedure addendum (SOPA) All drilling and sampling equipment and materials will be protected from the ground surface with clear plastic sheeting or will be placed on clean drill racks

Personnel installing monitoring wells need to be cognizant of the many factors influencing the screened intervals selected for wells For example, water table wells should have screens of sufficient length at the appropriate depth to monitor the water table Wells with slow recharge should have sufficient screen area to allow adequate sample volume However, long screened intervals should generally be avoided since they are of limited value for characterizing discrete zones of contamination.

Selection of well screen intervals may also depend on the suspected presence of light or dense immiscible layers of contaminants floating on the water table or residing at the bottom of a hydrostratigraphic unit (HSU) Screened intervals across different HSUs should generally be avoided particularly where there is a potential for cross-contamination between HSUs to occur

These factors must be addressed during project planning and the Field Sampling Plan (FSP) will normally provide rationale for the planned sampling Personnel installing monitoring wells should be familiar with the FSP and the rationale used in determining well screen intervals

5.1 EQUIPMENT AND MATERIALS

The following is a list of equipment and well materials for well installation

- Drill rig with appropriately sized drill bit augers, and/or rods
- High pressure steamer/sprayer
- Sand bailer
- Long-handled bristle brushes
- Wash/rinse tubs
- Phosphate-free, lab grade detergent (e g , Liquinox)
- Weighted tape measure
- Water level probe
- Distilled water
- Drums for containment of cuttings
- Appropriate health and safety equipment
- Field book
- Location map
- Boring log form
- Groundwater observation well report

5.2 DRILLING PROCEDURES

Boreholes for wells will be drilled by using a drill rig and drilling method capable of completing the well to the depth specified in the FSP All drilling equipment, including the drill rig, water tanks, and all down-hole equipment will be decontaminated according to SOP FO 3, General Equipment Decontamination and SOP FO 4, Heavy Equipment Decontamination The same decontamination procedure will also be followed between boreholes

Before drilling, test borings/wells will have been numbered, located, and identified by using stakes, or nails with flagging, on paved surfaces Drilling locations will be cleared for buried metal objects and utility interference according to SOP GT 10, Borehole Clearing Boreholes will be advanced from the ground surface to a predetermined target depth given in the FSP Boreholes drilled for wells will be logged stratigraphically by examination of the sample cuttings or core samples according to SOP GT 1, Logging Alluvial and Bedrock Material

If hollow-stem augers are used for alluvial wells, the boreholes will be augured as little as possible into claystone bedrock (approximately 6 inches or less), since the claystone bedrock cuttings may tend to be smeared along the side of the borehole in the alluvium Therefore, after the augers have been advanced to the bedrock contact, an appropriately sized drive sampler will be driven 2 feet into the claystone bedrock to provide a pilot hole for a 2-foot deep sediment sump The sediment sump will be a 2-foot-long piece of blank casing installed immediately beneath the screen in all wells The pilot hole will have a diameter no more than 1-inch greater than the outside diameter (OD) of the casing.

During the drilling process, the center bit will be removed slowly to prevent sand from entering (blowing into) the bottom auger In the event of sand blow-in, RFP potable water may be added to the inside of the augers to equalize the hydrostatic pressure of the formation water A record of the amount of water placed in the well will be kept so that it can be taken into account during well development

The inside diameter (I D) of the augers will be approximately 4 inches or more larger than the outside diameter (O D) of the casing, resulting in a 2-inch annulus around the casing Similarly, a 2-inch annulus will be provided around well screens and casings when wells are constructed in open portions of boreholes In open-hole installation (wells constructed in uncased boreholes), the use of stainless steel casing centralizers will be required to ensure the 2-inch annulus is maintained Centralizers should be provided above and below the well screen, but not within the bentonite seal Depending on the well depth and diameter, centralizers may also be required at intervals along the riser to provide a 2-inch grout annulus When hollow-stem augers are used, centralizers will only be required if the auger flights are not a sufficient size to ensure a 2-inch minimum annulus dimension on all sides of the screen

During the drilling operation, the cuttings and formation water from the boring will be placed in waste drums if required (see SOP FO 8, Handling of Drilling Fluids and Cuttings)

Single-cased wells will be used in the alluvial/unconfined aquifer Double casing will be required for bedrock wells installed in areas of potentially contaminated alluvial groundwater Surface casing will be installed through the alluvium according to SOP GT 3, Isolating Bedrock from the Alluvium with Grouted Surface Casing.

Boreholes for alluvial and bedrock wells will be drilled according to SOP GT.2, Drilling and Sampling Using Hollow-Stem Auger Techniques or SOP GT 4, Rotary Drilling and Rock Coring

5.3 WELL MATERIALS AND INSTALLATION PROCEDURES

5.3.1 Materials

5.3.1.1 <u>Well Casings</u>

Well casings will consist of new, threaded, flush-joint schedule 40 poly-vinyl chloride (PVC) unless another type of casing (e g , stainless steel) is required by the FSP or a

SOPA The well casing will extend from the top of the well screen to approximately 2 feet above ground surface The tops of all well casings will be fitted with slip-on or threaded PVC caps which can be easily removed by hand All joints within the casing string will be threaded Heat-welded joints, solvents, and/or gaskets will not be used Polytetra fluoroethylene (PTFE) tape will be wrapped around the joint threads to improve the seal All well casings will be free of foreign material and will be steam cleaned with approved water before use Steam-cleaned casings will be stored in plastic sleeves prior to use Casing with stamped or stenciled nomenclature will not be used

5.3.1.2 Well Screens

Well screens will consist of new threaded PVC pipe (unless another material [e.g , stainless steel] is required by the FSP or a SOPA) with 0 010-inch factory-machined slots or wrapped screen All well screens will have an I D equal to or greater than that of the well casing The wall thickness of PVC screen will be the same as that of the well casing A 2-foot deep sediment sump will be used beneath the screen A threaded cap or a slip-on cap secured with stainless steel screws will be provided at the bottom of the sump. Well screen with stamped or stenciled nomenclature will not be used

5.3.1.3 Filter Pack

The filter pack material will be chemically inert, rounded, silica sand of appropriate size for the well screen and host environment Grain size analyses of the unconsolidated formations underlying the site have indicated a 16-40 gradation is appropriate and will be used on the site unless the FSP or SOPA indicates otherwise The filter pack will extend approximately 2 feet above the top of the screen unless otherwise specified The final depth to the top of the filter pack will be measured directly by using a weighted tape measure and not by using volumetric calculation methods The volume placed will be recorded

5.3.1.4 Bentonite Seal

A bentonite seal will be installed above the filter pack The seal will consist of a layer of commercially available bentonite pellets that is at least 3 feet thick when measured immediately after placement, without allowance for swelling

5.3.1.5 Bentonite Grout

The annular space between the well casing and the borehole will be grouted from the top of the bentonite seal to ground surface. The grout will consist of high-solids reduced pH bentonite grout (American Colloid Pure Gold or approved equivalent) mixed in a powered mechanical grout mixer according to the grout manufacturer's recommendations. The grout will contain at least 30 percent solids by weight and have a minimum density of 9.9 pounds per gallon after mixing The density will be checked with a mud balance.

Grout will be placed outside of the monitoring well casing using a side-discharge tremie pipe located just above the top of the bentonite seal The grout will be pumped through the pipe until undiluted grout flows from the annular space at the ground surface The tremie pipe will then be removed and more grout added to compensate for settling After 24 hours, the site will be checked for grout settlement and more grout added to fill any depressions The total volume placed will be recorded

5.3.2 Installation Procedures

5.3.2.1 Alluvial Piezometer and Monitoring Well Installation

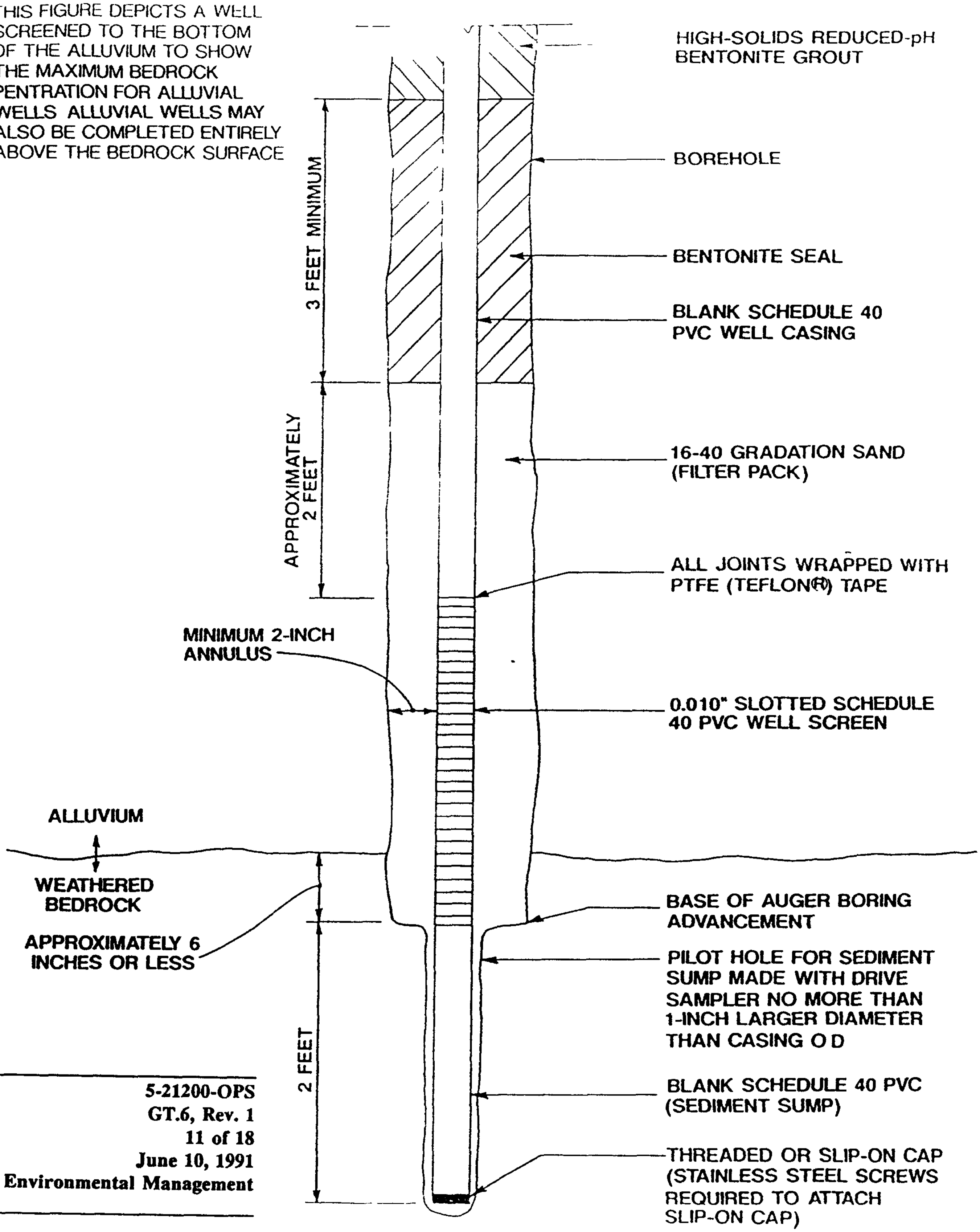
Figure GT 6-1 shows a schematic diagram of the lower portion of an alluvial well completion Monitoring well installation will begin after formation water and fine grained sediment have been bailed using a sand bailer until the water is relatively clear and free of sediments If granular soils do not blow into the bottom auger, raising the augers 1 to 2 feet above the bottom of the hole can help with the removal of muddy water from outside of the augers This will not work if the hole bottom caves or blows in

The borehole depth will then be measured to the nearest 0 1 foot, and the well assembly will be measured to the nearest 0.01 foot The portion of the well casing cut off at the top will be measured and subtracted from the total length supplied to determine the total well assembly length

Once the well assembly is in place, the filter pack will be added slowly to the zone below the water level in the borehole by tremie pipe If filter pack material is placed in wells above the water level in the borehole, a tremie pipe will not be required inside of hollow-stem augers A tremie pipe will be required for all filter placement in open hole completions The filter pack will be added in 1- to 2-foot increments Similarly, the augers will be raised in 1- to 2-foot increments so that the sand level is always at or slightly above the bottom of the augers Depth measurements of the top of the filter material will be taken continuously in the well annulus as the filter is placed The final depth to the top of the filter pack will be approximately 2 feet above the top of the well screen and will be directly measured by a weighted tape measure The weight on the measure tape will be stainless steel in the event that it accidentally becomes embedded in the filter pack If bridging of the filter material occurs in the well annulus or tremie pipe

NOTE

THIS FIGURE DEPICTS A WELL SCREENED TO THE BOTTOM OF THE ALLUVIUM TO SHOW THE MAXIMUM BEDROCK PENTRATION FOR ALLUVIAL WELLS ALLUVIAL WELLS MAY ALSO BE COMPLETED ENTIRELY ABOVE THE BEDROCK SURFACE



NOT TO SCALE

FIGURE GT 6-1 - SCHEMATIC DIAGRAM OF ALLUVIAL MONITORING WELL COMPLETION during placement, the bridged material will be broken loose mechanically by shaking augers and/or well assembly Bridged material in the annulus may also be broken loose by probing with a 1-inch-diameter tremie pipe If both of these methods are unsuccessful, distilled water may be pumped through the 1-inch tremie pipe to dislodge the bridged material. A record of the amount of water placed in the well will be kept so that it can be taken into account during well development The volume of filter material placed will also be recorded

A minimum 3-foot bentonite pellet seal (before swelling) will be installed immediately above the filter pack If the bentonite pellet seal will be placed below the water table, it will be installed through a tremie pipe The bentonite pellets will be added slowly to reduce the chances for bridging of the pellets inside the tremie The augers will be raised approximately 1 foot above the filter pack prior to adding the bentonite pellets The top of the bentonite seal should never be above the base of the augers If the bentonite seal is placed above the water level in the borehole, the pellets may be allowed to free-fall into the borehole if hollow-stem augers are being used The bentonite will be hydrated using 5 gallons of distilled water after the base of the augers are raised approximately 1 foot above the top of the bentonite seal The completed bentonite seal will be allowed to hydrate for approximately 30 minutes before proceeding with the grouting operation

Bentonite grout backfill will be placed from the top of the bentonite seal to the ground surface The grout mixture will conform to the specifications outlined in Subsection 5 3 1 5, Bentonite Grout The grout will be tremied into the well annulus using a side-discharge tremie until it is completely full The volume of grout placed will be recorded The well casing will be checked for plumb by use of a weighted tape lowered from the center of the casing If the tape touches the side of the casing prior to reaching the bottom, the casing will be shifted as much as possible to a vertical alignment and held in place while the grout sets up and hardens After settlement of the bentonite grout has been allowed for 24 to 48 hours, the protective steel casing will be embedded in cement-bentonite grout or nonshrink concrete The cement-containing grout will occupy the upper 1 1/2 to 3 feet of the well annulus to anchor the protective casing This may require removing some of the bentonite grout from the upper 1 1/2 to 3 feet of the well annulus If the upper grout surface is dehydrated, it will either be removed or rehydrated by adding water and waiting approximately 30 minutes

5.3.2.2 Bedrock Piezometer and Monitoring Well Installation

Figure GT 6-2 shows a schematic diagram of the lower portion of a bedrock well completion Bedrock piezometers and monitoring well installations will be similar to the alluvial well installation procedures except that a surface casing will be provided through the alluvium to guard against potential cross-contamination of bedrock aquifers by contaminated alluvial groundwater The surface casing will extend from the ground surface to at least 3 feet below the bedrock alluvium contact This casing will be installed according to SOP GT.3, Isolating Bedrock from the Alluvium with Grouted Surface Casing

If rotary drilling methods (see SOP GT 4, Rotary Drilling and Rock Coring) are required, the installation procedures will be similar except that the well may be completed in an open hole instead of inside of hollow-stem augers The well string will be suspended approximately 2 inches above the bottom of the borehole prior to installing the filter pack This will reduce bending of the well assembly and minimize the potential for collapse of the casing due to the weight of fluid in the annulus Stainless steel centralizers will be placed at 20-foot-maximum spacing for wells completed in open holes

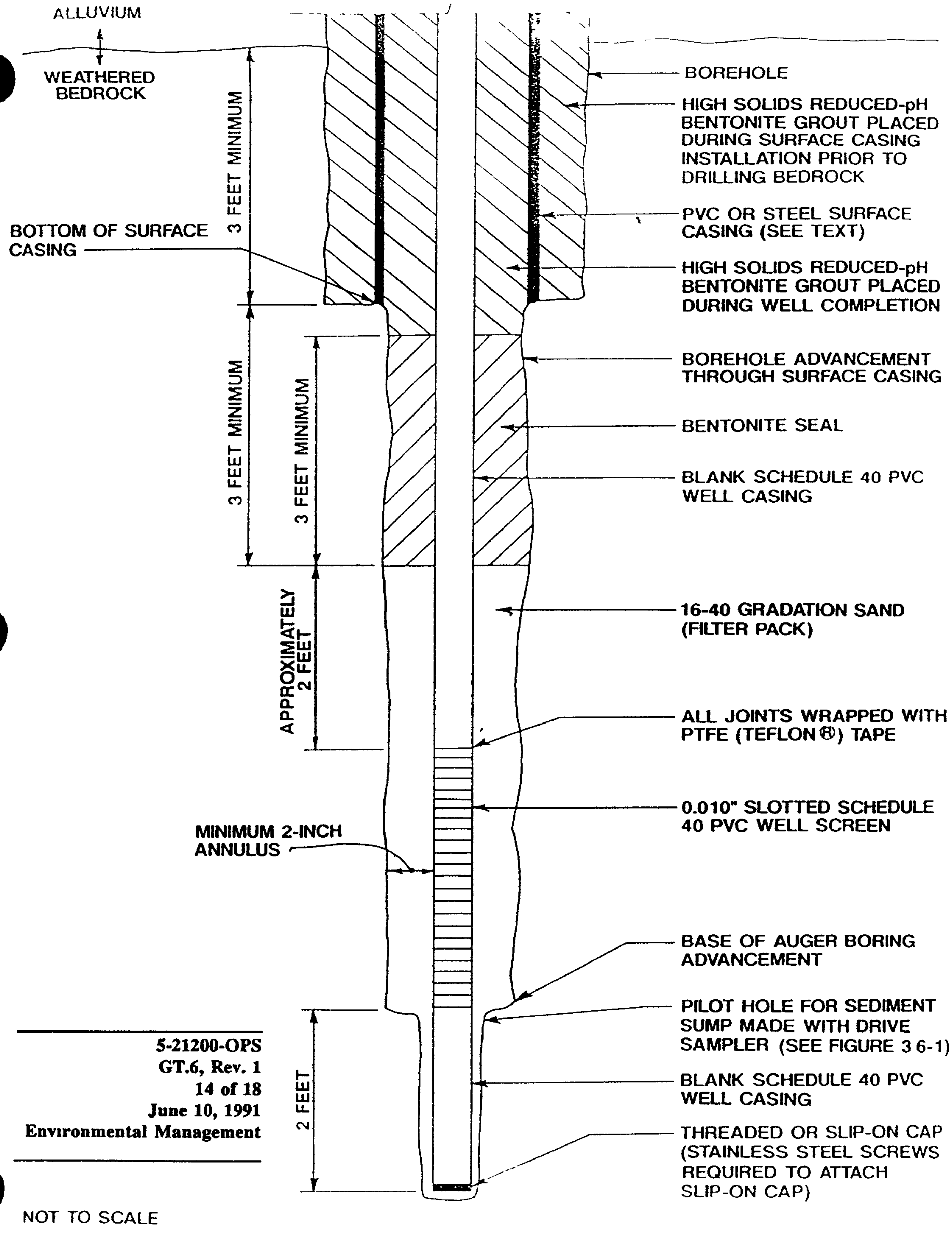


FIGURE GT 6-2 - SCHEMATIC DIAGRAM OF BEDROCK MONITORING WELL COMPLETION

5.3.2.3 Well Features at Ground Surface

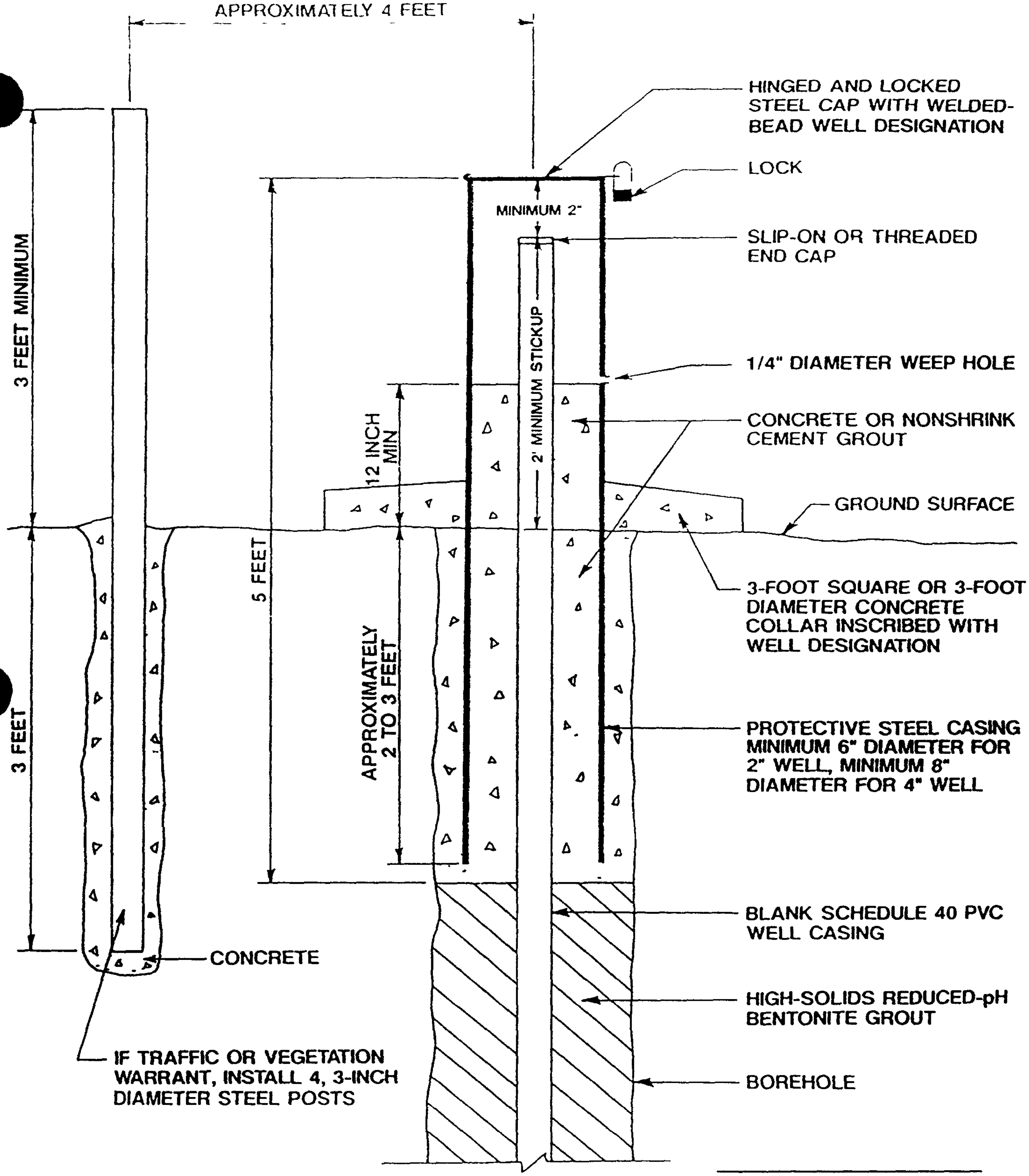
Figure GT 6-3 shows a schematic diagram of well features at the ground surface A 5-foot-long protective steel casing with a hinged and locking steel cap will be installed over the monitoring well riser that projects above the ground surface between 24 and 48 hours after initial grout placement The protective casing will have a minimum 8-inch I D for 4-inch wells and a minimum 6-inch I D for 2-inch wells The well designation will be welded on the protective casing

The bottom of the protective casing will be embedded 2 to 3 feet below the ground surface in concrete or cement grout Prior to installing the protective casing, the well will be checked for alignment by lowering a 5-foot-long, 1 1/2-inch diameter bailer down the entire depth of the well If the bailer hangs up, the EG&G project manager will decide whether or not the well needs to be reconstructed.

The annulus between the well riser and the steel protective casing will be filled with nonshrink cement grout or concrete to a minimum of 12 inches above the ground surface, and a 1/4-inch-diameter hole will be drilled in the protective casing just above the grout or concrete surface to allow drainage

At the same time the protective steel casing is grouted or concreted in place, an external concrete collar approximately 3 feet square will be placed around the protective casing at the ground surface The well designation will be scribed in the concrete before it sets. The collar will be graded to slope away from the casing in all directions

When traffic conditions or vegetation warrant extra protection, four 3-inch-diameter steel posts will be installed The posts will be located radially from the well casing at a distance



NOT TO SCALE

FIGURE GT 6-3 SCHEMATIC DIAGRAM OF WELL FEATURES AT GROUND SURFACE of approximately 4 feet They will be embedded in concrete 3 feet below the ground surface with a minimum of 3 feet sticking up above the ground Installation is required within 48 hours of well installation In areas of high vegetation, the posts will be flagged

6.0 DOCUMENTATION

The installation of monitoring wells and piezometers will be documented on groundwater monitoring well and piezometer report forms Drilling information will be documented on Rocky Flats Plant Borehole Log Forms (SOP GT 1, Logging Alluvial and Bedrock Material) and on hollow-stem auger or rotary and core drilling field activities report forms (SOPs GT 2 and GT 4) Besides the drilling and borehole information required by these other SOPs, the following documentation will be recorded on the Groundwater Monitoring Well and Piezometer Report Form, Form GT.6A. Location references will use the State Plane Coordinate System and elevations will be feet above mean sea level (USGS datum)

- Elevation of ground surface
- Elevation of top of surface casing/riser pipe
- Height of top of surface casing/riser pipe above ground surface
- Depth of surface seal below ground surface
- Type of surface seal
- Type and size of surface casing
- Depth of surface casing below ground
- Types/depths of centralizers
- Type and size of riser pipe
- Diameter of borehole
- Depth of borehole
- Type/volume of backfill
- Elev /depth top of seal

- Type of seal
- Elev /depth bottom of seal
- Type/volume of filter pack
- Depth of top of filter pack
- Elev /depth top of screened section
- Type of screened section
- Screen openings
- I D of screened section
- Elev /depth of bottom of screened section
- Length of blank section below screen
- Elev /depth of bottom of plugged blank section
- Elev /depth of bottom of sand column
- Type of backfill below observation pipe
- Elev / depth of bottom of hole

GROUNDWATER MONITORING WELL AND PIEZOMETER REPORT

PROJECT ____________________

LOCATION ____________________

Date Completed ____________ Original Depth ____________

Inspected By ____________ Date ____________

Checked By ____________ Date ____________

Page ______ of ______

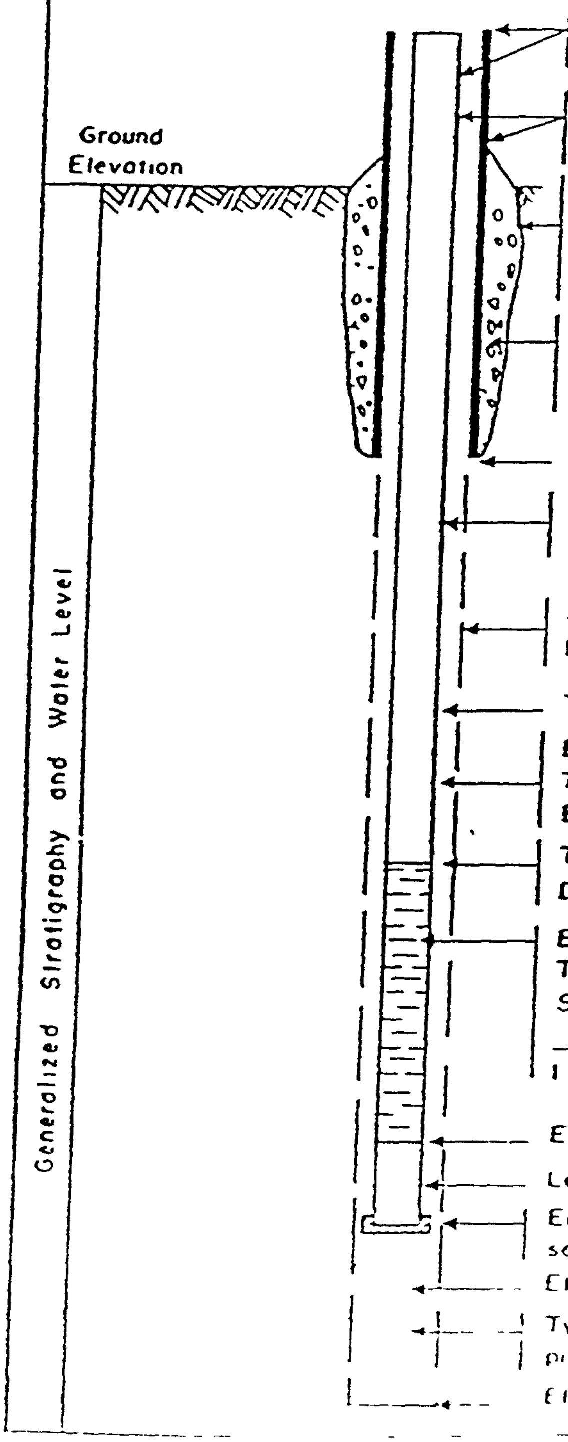
Well No ____________

Aquifer ____________

____

Depth Interval ____________

NOTE CENTRALIZER DEPTHS



Elevation of top of surface casing / riser pipe. ____________

Height of top of surface casing / riser pipe above ground surface ____________

Depth of surface seal below ground surface ____________

Type of surface seal ____________

____

I D of surface casing ____________

Type of surface casing ____________

____

Depth of surface casing below ground ____________

I D. of riser pipe. ____________

Type of riser pipe ____________

____

Diameter of borehole ____________

Depth of borehole ____________

Type of backfill ____________

Elev./depth top of seal ____________

Type of seal ____________

Elev./depth bottom of seal ____________

Type of filter pack ____________

Depth of top of filter pack. ____________

Elev./depth top of screened section. ____________

Type of screened section ____________

Screen openings ____________

____

I D of screened section ____________

Elev /depth bottom of screened section ____________

Length of blank section ____________

Elev / depth bottom of plugged blank section ____________

Elev / depth bottom of sand column ____________

Type of backfill below observation pipe ____________

Elev / depth of hole ____________

EG&G ROCKY FLATS PLANT	Manual:	5-21200-OPS
EMAD MANUAL OPERATION SOP	Procedure No.:	GT.10, Rev. 1
	Page:	1 of 16
	Effective Date:	June 10, 1991
Category 2	Organization.	Environmental Management

TITLE
BOREHOLE CLEARING

Approved By

____________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

LIST OF TABLES

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes procedures that will be used at the Rocky Flats Plant (RFP) for clearing drill sites and intrusive work sites within Individual Hazardous Substance Sites (IHSSs) Geophysical clearing will be implemented to ensure that selected locations are free of buried metal objects to a depth of 18 feet and metal utility lines This SOP describes geophysical, administrative clearance techniques, and geophysical data reduction and analyses that will be used for field data collection and documentation

The geophysical techniques that are employed involve electromagnetic (EM) techniques, a magnetic locator, and ground penetrating radar (GPR) EM and magnetic surveys can be used for identifying areas where subsurface metal objects might be located The techniques indicate contrasts in conditions due to variations in the electrical conductivity or magnetic properties of subsurface materials. GPR is useful for detection of shallow variations in the subsurface dielectric constant

A magnetic locator can be used when the clearing depth-of-interest is 18 inches or less EM techniques and a magnetic locator will both be used when the clearing depth-of-interest is deeper than 18 inches Generally, GPR is applicable to depths of 0-6 feet at the RFP site

3.0 RESPONSIBILITIES AND QUALIFICATIONS

Oversight and supervision of the geophysical surveys will be conducted by EG&G personnel Project staff performing these surveys will be trained geophysicists or trained personnel with a significant amount of geophysical field experience The subcontractor's project manager will document personnel qualifications related to this procedure in the subcontractor's project QA files

The subcontractor's project manager is responsible for obtaining administrative borehole clearance

4.0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure

A Compendium of Superfund Field Operations Methods EPA/540/P-87/001 December 1987

Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA Interim Final October 1988

RCRA Facility Investigation Guidance EPA. Interim Final May 1989

4.2 INTERNAL REFERENCES

GT 18 - Surface Geophysical Surveys

5.0 GEOPHYSICAL EQUIPMENT AND PROCEDURES

5.1 INTRODUCTION

Borehole clearing, using geophysical methods, will be employed within an IHSS where buried trenches are known to exist or where buried metal may be present Surface geophysical surveys have been conducted at the RFP Research of these previous geophysical surveys should be exhausted prior to conducting the following procedures

Instruments used for geophysical clearing will be recalibrated and recertified, if required The date of the manufacturer's last calibration and certification will be documented on the Borehole Clearing Analysis Form (Form GT 10A)

Each instrument will have a field calibration check prior to and after field use Personnel performing the field calibration check should refer to the manufacturer's instructions An example of a field calibration check would be to use the instrument over a known buried object If the instrument does not respond appropriately, the instrument should be returned to the manufacturer for recalibration and recertification

Geophysical methods have limitations which must be considered when implementing a geophysical survey In some instances, the limitations may be sufficient to make the geophysical results ambiguous or non-conclusive Therefore, it is imperative that an experienced geophysical operator conduct the clearing of boreholes

Electromagnetics, magnetics, and GPR are influenced by surface cultural features, such as fences, power lines, and metallic debris. These cultural effects can be mitigated by the use of a directional magnetic locator, which responds to a magnetic gradient However, if borehole clearing is being performed within 40 to 50 feet of a cultural feature, reliable geophysical clearing may be difficult to achieve In cases where a site cannot be definitively cleared, the location should be moved to the nearest clearable location

5.2 ELECTROMAGNETICS

An EM survey can be used to detect ferrous and nonferrous metals as well as areas of high inorganic contamination This method involves the induction of electrical current into the ground A small alternating current passing through a transmitter coil produces a primary magnetic field Through inductive coupling, the primary magnetic field produces small eddy currents in the subsurface which, in turn, create their own secondary magnetic field The receiver coil senses both the primary and secondary fields This results in an output voltage that is linearly related to the terrain conductivity The instrument then converts the voltage to a ground conductivity value which can be recorded by a strip recorder or digital logger Electrical conductivity is a function of the soil or rock composition, the porosity and permeability of the rock units, and the conductivity of the fluids filling the pore spaces The conductivity values are subsequently plotted on a map so that their variation over the site can be analyzed

A Geonics EM-31, EM-38, or equivalent ground conductivity meter will be used for the EM surveys. Through the use of the horizontal dipole mode (HDM), the EM-31 has a depth penetration to 9 feet When deeper penetration is required, the vertical dipole mode (VDM) will be used in addition to the HDM This scenario will provide high resolution detection of objects to 9 feet and will allow detection of larger metal objects to 18 feet The size of a metal object that can be detected is proportional to the depth of burial. For shallow investigation (less than 9 feet), the HDM provides the greatest resolution and can normally detect objects as small as a 1-foot length of rebar. By monitoring the in-phase component of the induced magnetic field, small amounts of subsurface metal can be detected. For high-resolution of depths less than 5 feet, the EM-38 can be used. Table GT 10-1 summarizes instrument modes and applications

Table GT 10-1
EM INSTRUMENT MODE APPLICATION

Instrument	Mode	Depth of Penetration (ft)	Approximate Size of Detected Object
EM-31	HDM	9	1-foot piece of rebar
	VDM	18	Steel drum
EM-38	HDM	2.5	
	VDM	5	

5.2.1 List of Necessary Equipment

The following is a list of equipment that will be necessary to complete the EM survey

- A Geonics EM-31, EM-38, or equivalent terrain conductivity meter
- Digital logger and/or analog strip recorder (when data collection is over large grid area)
- Appropriate health and safety equipment
- Wood stakes or lath
- Flagging
- Field notebook
- Pens with nonwater-soluble ink
- Form GT 10A, Borehole Clearing Analysis (see Section 7 0, Documentation)

5.2.2 Field Procedure

A standard field procedure for conducting an EM survey is initiated by a reconnaissance survey of each drill site The survey will involve a review of existing magnetic data at the site, a review of the site utility plans, an acknowledgement from the telephone and utility site locators that the site is clear of these utilities, and a field check for overhead wires, pipes, or other objects that may restrict drilling operations Note surface conditions of site on Form GT 10A (see Section 7 0, Documentation) including excessive and/or large metal objects on the ground surface and large variations in topography Following the instrument manufacturer's instructions, initiate site survey traverse on an approximate 1-foot grid, clearing a minimum of 6 feet around the drilling location stake When anomalous values indicative of buried metal are observed, record the anomaly on Form GT 10A If an anomaly is not present, document results on Form GT 10A

Drilling locations with anomalous values will require moving the location to the nearest "clear" area By using the above procedures, determine an area within 50 feet of the original drilling location that is free of anomalies Mark the new drilling location with a wood stake and document new location on Form GT.10A Notify the project site manager of the new location

For larger areas or for locating buried trenches or pits, follow a surveyed grid pattern when traversing with the EM instrument If the grid is not surveyed prior to the EM traverse, place a wood stake marker at the end of each traverse and document the marker location on the field data record (Form GT 10A) All EM traverses should be documented on a field map during the survey For larger areas, a portable computer may be required to quickly analyze the data and facilitate the location of additional survey lines

5.3 MAGNETIC LOCATOR

A magnetic locator detects magnetic fields associated with certain objects The depth of investigation depends on the size of the object The Schonstedt magnetic locator, for example, can detect well casings up to 15 feet deep, however, a 1 1/4-inch nail can be detected only to a depth of 8 inches.

A magnetic locator responds to the magnetic gradient between two magnetic field sensors (A and B) If no anomalies exist, the magnetic field between sensors A and B is balanced, and a 40 Hz frequency signal is heard on the magnetic locator's audio output This frequency output (40 Hz) is the ambient magnetic field of the earth However, when the magnetic field becomes stronger at sensor A (located at the bottom of the locator) than at sensor B, the output signal increases in frequency. When the tip of the locator is directly over the ferrous object, the audio signal increases to its highest frequency

5.3.1 List of Necessary Equipment

The following is a list of equipment that will be necessary to complete the geophysical survey

- Schonstedt Model GA-52B magnetic locator or equivalent
- Appropriate health and safety equipment
- Wood stakes or lath
- Flagging
- Field notebook
- Pens
- Form GT 10A, Borehole Clearing Analysis (see Section 7 0, Documentation)

5.3.2 Field Procedure

The field procedures for a magnetic survey are the same as the procedures described for the EM survey (Subsection 5 2.2)

5.4 GROUND PENETRATING RADAR

Ground penetrating radar (GPR) has been used for mapping shallow geologic interfaces, delineating shallow bedrock, locating voids in concrete or limestone, and finding buried pipeline or reinforcement bars

GPR involves a system that transmits electromagnetic pulses into the ground from an antenna near the surface These pulses are reflected from a variety of subsurface interfaces back to a receiver As the antenna is towed along a survey line, the GPR signals are processed and displayed on a graphic recorder The displayed data is a two-dimensional continuous profile along the surveyed line depicting time versus distance The display is very similar to a geologic section, except that the record is a time section rather than a depth section

GPR has excellent resolution of subsurface features when favorable conditions exist However, actual depth penetration is highly site-specific and depends on the near-surface soil conductivity Highly conductive soils, such as clays, can reduce penetration to less than three feet Less conductive materials, such as limestone, will allow depth penetration of 30 - 50 feet

5.4.1 List of Necessary Equipment

The following is a list of equipment that will be necessary to complete a GPR survey

- GSSI SIR System-3 or equivalent radar system
- Flagging
- Lath or wooden stakes
- Field notebook
- Pens with nonwater-soluble ink
- Measuring tape (200 feet minimum) (note a measuring wheel can be substituted for relatively smooth surfaces)
- Extra paper for profile recorder
- Extra stylus(s) for profile recorder

- Form GT 10A, Borehole Clearing Analysis (See Section 7 0, Documentation)

5.4.2 FIELD PROCEDURE

A standard field procedure for collecting GPR data is described below Prior to GPR data collection, two preliminary procedures must be conducted These are

- Design appropriate field parameters, given the purpose of the survey (orientation of lines or grid, grid spacing, frequency or antenna, antenna shielding, etc)

- Locate endpoints along each line in addition to any other points of interest, and denote these locations in the field with lath or other wood stakes

Design of appropriate field parameters must consider the following·

- The antenna and associated transmitter frequency used must optimize the penetration depth and required resolution given the survey purpose Typical frequencies are 80 Mhz, 100 Mhz, 120 Mhz, 300 Mhz, 500 Mhz, and 1000 Mhz. Higher frequency antennas allow greater subsurface resolution, but penetration is reduced over that of lower frequencies Surveys should be designed to have a minimum of two antenna frequencies available, to optimize results For most clearing applications, a 300 Mhz or 120 Mhz antenna will be appropriate

- For grid areas, intraline spacing affects resolution, a spacing of 2 to 20 feet is commonly used for clearing applications Actual spacing chosen must consider overall project objectives

- Method of antenna towing must be evaluated given the site conditions For smooth surfaces or terrain, the antenna can be towed directly on the surface For areas with significant vegetation or surface stones and rocks, the antenna may need to be suspended 6-18 inches above the ground or carried in a plastic non-conductive wagon, to prevent antenna damage and potentially dubious GPR data collection

- Antenna shielding should be considered and appropriate shielding provided given the site conditions Surface features such as fences, power lines, etc. can cause interfering reflections on the radar record

A standard field procedure for conducting a GPR survey is described below

1 Perform a visual survey along the proposed lines The visual survey will include a review of site utility plans, check for overhead wires, check for manhole covers, buried cables, buried gas line indicators, or cased monitoring wells, and have site locators confirm the presence of any possible telephone and utility features Note features in field notebook

2. Note excessive amounts of large pieces of metal on the ground surface in field notebook

3 Note large nearby variations in topography or building (within 50 feet) in notebook

4 Note moisture content of surveyed media, in addition to relative clay content, as these will effect penetration depths

5 Conduct a test line using manufacturer's procedures Instrument settings must be optimized to obtain appropriate data given project goals Specific recording parameters that must be optimized include, but are not limited to, the following

- radar scan speed
- signal range gain
- high and low pass filter settings
- time range for recording
- transmitter pulse rate
- recording printer speed
- antenna towing speed

Instrument settings should be varied during the test line to determine the optimum recording parameters When possible, the test line should be conducted over a known buried feature in the survey area to help instrument setting optimization, and help calibrate penetration depths

6 Initiate site survey traverse Beginning at GPR line endpoint, tow antenna along line with appropriate speed determined from test line, and using optimum instrument settings determined from test line Continue above procedure for entire line and subsequent grid lines

7 If hard copies of each line of data from printer are made, label all notations on the record to correspond to notes made in the field notebook, including recording parameters.

8 Permanent copies of this GPR data must be retained digitally on tape or disk, or on hard copy plots

5.5 DATA ANALYSIS

When the anticipated hazards are isolated pieces of metal, borehole locations will be cleared to a minimum of 6 feet around the drilling location stake In these cases, data will not be retained for later analysis, but the results will be documented on Form GT 10A If an anomalous area within 6 feet of the borehole location stake is identified, the borehole location will be changed to an anomaly-free area within 50 feet of the original borehole location to minimize the possibility of contact with any anomalous material below the surface

When the hazard is buried trenches or pits, larger areas will have to be geophysically surveyed to clear borehole locations In these cases, electromagnetic data will be collected with a digital data logger. The data will be transferred to a personal computer for analysis. Adjustments to the boring location (if required) will be made after the data are analyzed and interpreted

In both of the above cases, Form GT 10A will be used to document the procedures and reasoning for the relocation or approval of a borehole location

At all times, geophysical data will be collected and interpreted in a conservative and prudent manner Additionally, appropriate levels of caution will be exercised by all field crews involved in intrusive activities, even on geophysically "cleared" boring locations

6.0 ADMINISTRATIVE BOREHOLE CLEARANCE

Administrative borehole clearance will be required for drilling operations at the RFP and will consist of obtaining work and excavation permits. Copies of these forms are included in Section 7 0, Documentation

6.1 RADIOLOGICAL/HEALTH & SAFETY WORK PERMIT

Work permits will be required for drilling operations in all restricted access areas, which include IHSSs These permits will be issued by the EG&G construction manager and will be valid for one week of drilling operations (see Section 7 0, Documentation) If field operations extend beyond a week's time, a request for an additional work permit will be submitted to the construction manager This request will include details of the drilling operations planned for the following week

Daily work permits will be required for all drilling operations within the perimeter security zone (PSZ)

The permitting process will consist of the construction manager reviewing the field operations plan (FOP), EG&G personnel clearing underground utilities, and screening for low energy radiation

The work permit will be kept at the drill site during the drilling operation

Instructions and requirements for the use of a Radiological/Health & Safety Work Permit (see Section 7 0, Documentation) are contained in H&S 6 05 Radiological/H&S Work Permit available through EG&G

6.2 EXCAVATION PERMIT

Excavation permits will be required for drilling or excavating deeper than 18 inches These permits will also be issued by the EG&G construction manager A permit will be required for each project and will be valid for 60 days The excavation permit will also be kept at the drill site

7.0 DOCUMENTATION

A permanent record of the implementation of this SOP will be kept by documenting field observations and data The date of the manufacturer's most recent calibration and certification will be documented if this information is available Field calibration checks, geophysical observations, and data will be documented on the Borehole Clearing Analysis Form (Form GT 10A) Administrative clearances will be documented on the Radiological/Health and Safety Work Permit, and the Rocky Flats Excavation Permit

U.S. DEPARTMENT OF ENERGY ROCKY FLATS PLANT **FORM GT 10A**

BOREHOLE CLEARING ANALYSIS

Project Name ______________________ Date ____________

Project Number ____________________ Operator ____________________

Survey Type ____________________ Instrumentation ____________________

Date of last calibration and instrument certification ____________________

Field calibration dates ____________________

Location (Borehole ID and Coordinates (if Available)	Surface Condition	Max Depth of Interest	Anomaly Present (Y/N)	Comments or Action

(4011 REV)(GT10REV 1))(06-07-91)

EG&G ROCKY FLATS PLANT	Manual:	5-21200-OPS
EMAD MANUAL PROCEDURE SOP	Procedure No..	GT.15, Rev. D
	Page:	1 of 5
	Effective Date:	June 10, 1991
Category 2	Organization.	Environmental Management

TITLE
GEOPHYSICAL BOREHOLE LOGGING

Approved By:

______________________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes procedures that will be used at the Rocky Flats Plant (RFP) for conducting downhole geophysical logging Geophysical logging may be accomplished by employing a variety of downhole instruments. Geophysical logging methods may include, but are not limited to, temperature log, caliper log, density log, focused log, induction log, micro log, neutron log, sidewall neutron log, spontaneous potential log, acoustic log, variable density and full-waveform sonic log, dip log, gamma ray log, or collar log

Accurate and dependable quantitative analysis of the data requires that the logging operation be of the best possible quality. The following sections describe all procedures that will be used to collect and document downhole geophysical data

3.0 RESPONSIBILITIES AND QUALIFICATIONS

Oversight and supervision of geophysical logging operations will be conducted by an EG&G or subcontractor representative Downhole logging is to be performed by a qualified and reputable firm with geophysical logging expertise

Prior to any geophysical logging operation, the EG&G or subcontractor representative will contact the manager and/or supervisory operator of the logging service company to review the logging program and supply the information necessary to have all applicable equipment at the drill site when required An appropriate suite of downhole logs will be agreed upon based on the project-specific objectives presented in the work plans The subcontractor will have ultimate responsibility for data quality.

4.0 REFERENCES

4.1 INTERNAL REFERENCES

Related SOPs cross-referenced in this SOP are as follows

- SOP FO 3, General Equipment Decontamination
- SOP FO 4, Heavy Equipment Decontamination
- SOP FO 16, Field Radiological Measurements

5.0 PROCEDURES

The use of geophysical logging will be discussed in the project work plans Given the project-specific objectives and the subsurface information required, an appropriate suite of logs will be proposed and agreed upon The EG&G or subcontractor representative will subsequently provide the logging service company with all pertinent information required to conduct the downhole logging (e g., objectives, types of lithologies, etc) The logging company will maintain access to any additional logging equipment requested by the EG&G or subcontractor representative and will provide the additional logging service within eight hours of the request

The subcontractor will notify the appropriate EG&G personnel of the initiation of downhole logging activities, including Security and EG&G Radiation Protection Technicians (RPTs) or RPT designated representatives Prior to entry onto the RFP, downhole instruments will be examined by Security Particular emphasis will be placed on checking the downhole instruments that have radioactive sources The logging service company will be required to present documentation of downhole source certification If a radioactive source will be used, the logging truck will carry the appropriate placards, and the source container will be appropriately labeled

When the logging service company arrives at the drill site, the EG&G or subcontractor representative will review the logging program with the logging operator and provide information necessary for completing the Borehole Geophysical Logging Form (Form GT 15A) Logging Units will be computerized and logs will be digitally recorded on tape or disk The tapes or disks will become the property of EG&G and their final disposition will be determined at the end of the project

Field prints of all logs will be made, no portion of the log run, including calibration steps, will be destroyed Field prints will be collected by the subcontractor's representative at the end of each day No hole will be left unlogged at the end of the day

The EG&G or subcontractor representative, as well as any appropriate EG&G personnel, will have access to the logging unit at all times in order to monitor logging activities The subcontractor's field supervisor is responsible for notifying the logging company as soon as a hole is available for logging. Holes should be left open for as little time as possible In the event of a stuck tool, every effort will be made to recover the tool. If the tool contains a radioactive source and cannot be recovered, State of Colorado guidelines will be followed in order to recover as much of the tool as possible, or the tool will be cemented in place

After completion of logging activities in a given borehole, all logging equipment will be decontaminated in accordance with SOP FO.3, General Equipment Decontamination and SOP FO 4, Heavy Equipment Decontamination After decontamination, radiation monitoring activities will be conducted by EG&G RPTs or RPT designated representatives Monitoring will be conducted for geophysical logging equipment and personnel before they leave the work area All radiation monitoring will be done in accordance with SOP FO 16, Field Radiological Measurements and the Health and Safety Program Plan After radiation monitoring, all equipment and personnel will proceed to the decontamination facility for final decontamination

6.0 DOCUMENTATION

Logging information will be documented on the Borehole Geophysical Logging Form (Form GT 15A) and the Quality Control Check List (Form GT 15B) Prior to releasing the logging operator, the EG&G or subcontractor representative will check these forms for completeness An "N/A" can be substituted for a check on the Quality Control Check List if the item is not applicable to the logging run in progress Any unmarked items will be discussed and recorded in the "REMARKS" section When the EG&G or subcontractor representative is satisfied with the performance of the logging operation, he/she and the logging operator both will sign and date the Quality Control Check List Forms will be completed in the field without transcribing from a field book or other document This technique reduces offsite work hours for the geologist or geophysicist, reduces the chance for errors in manual copying, and allows the completed document to be field-reviewed immediately after logging.

High quality, reproducible logs will be submitted by the logging service company to the subcontractor's office within 10 working days after the logging run is completed.

6.1 EQUIPMENT CALIBRATION

The geophysical logging company will calibrate all logging equipment before and after the logging run The geophysical logging company will provide documentation of all shop calibrations, surface calibrations, and calibrations performed before and after the logging run to the subcontractor The geophysical logging company will possess documentation of downhole instrument source certification for any radioactive tools.

BOREHOLE GEOPHYSICAL LOGGING FORM

LOG RUNS

Date ______________

- [ ] Induction
- [ ] Natural Gamma
- [ ] Neutron
- [ ] Spontaneous Potential
- [ ] Short-Normal Resistivity
- [ ] Long-Normal Resistivity
- [ ] Caliper
- [ ] Temperature
- [ ] Gamma-Gamma Density
- [ ] Full-Waveform Sonic
- [ ] Other______________

Project No ______________
Project Name ______________
Sample Location ______________

____

Weather Conditions ______________
Observations/Comments ______________
Hole Conditions ______________
Fluid in Hole Y N
Fluid Temp ______________
Fluid Resistivity ______________
Casing Y N
Type of Casing ______________
Casing ID ______________
Bit Size

LOG TYPE	DEPTH (feet)		TIME (hour)	
	From	To	Begin	End

Remarks

Supervisor ______________
Signature ______________
Company ______________

Logging Operator ______________
Signature ______________
Company ______________

BOREHOLE GEOPHYSICAL LOGGING QUALITY CONTROL CHECK LIST

Logging engineer shall check all items No 1 to 36 applicable to the logging operation
Items unchecked shall be discussed and recorded in the "REMARKS" section
Items not applicable will be designated "N/A", the Logging Operator and supervisor representative will sign and date the checklist upon completion of the logging operations and this checklist
Any additional comments should be included on the "REMARKS" section

Date

GENERAL	No	
Calibration before and after each survey	1	
Casing I D size, bit size, and hole size recorded	2	
Tool description and designation included in log heading	3	
Depths at which any major changes in mud properties occurred are included in remarks section of log heading	4	
Depth at which any hole or casing size changes occur are included in remarks section of log heading	5	
Depth at which any unusual hole conditions were encountered are included in remarks section of log heading	6	
Abnormal or unusual conditions noted in "remarks" section	7	
Logging operator has copies of nearby drill holes for comparison	8	
Logging operator has copies of previous log runs of this drill hole	9	
Log heading completely filled out	10	
Appropriate logging scales chosen and recorded for all logs	11	
All scale changes noted on log at corresponding depths	12	
Base of casing detected and labeled on all logs (if present)	13	
All curves labeled	14	
Logging speeds recorded and conform to clients request or service company specification	15	
NEUTRON AND NATURAL GAMMA RAY LOGS		
Caliper recorded	16	
Background gamma ray recorded	17	
SPONTANEOUS POTENTIAL		
Ground electron in a stable position	18	
Adequate scale for SP sensitivity approximately 5 divisions deflections from shale line to clean sand line	19	
SP baseline shifts greater than one division corrected abruptly and labeled	20	
If SP abnormal re-run with survey current off and ground electrode checked	21	
While on bottom prior to logging SP recorded and labeled with current on and off	22	
RESISTIVITY LOGS		
Mud or borehole fluid resistivity recorded	23	
CALIPER LOG		
Magnitude (size) of changes in borehole diameter capable of being distinguished are specified on log	24	
Recording made in casing (if present) as a check of calibration	25	
TEMPERATURE LOG		
Log recorded while going in hole	26	
Flow line, mud pit, and air temperature measured and recorded	27	
GAMMA-GAMMA DENSITY LOG		
Caliper recorded	28	
Background gamma ray recorded	29	
Bulk density (g/cc) and porosity (%) curves recorded	30	
Matrix density and fluid density labeled	31	
Correction curves (g/cc) recorded	32	
SONIC LOG		
Adequate scale for velocity sensitivity	33	
INDUCTION LOG		
Adequate scale for conductivity sensitivity	34	
DIPMETER		
Adequate scale for sensitivity	35	
FRACTURE LOG		
Adequate scale for sensitivity	36	

BOREHOLE GEOPHYSICAL LOGGING
QUALITY CONTROL CHECK LIST

Date ____________________

No.	QUALITY CONTROL CHECK LIST

Additional Comments

Supervisor. ____________________
Signature ____________________
Company ____________________

Logging Operator ____________________
Signature ____________________
Company ____________________

EG&G ROCKY FLATS PLANT	Manual:	5-21200-OPS
EMAD MANUAL OPERATION SOP	Procedure No.:	GT.17, Rev. D
	Page:	1 of 6
	Effective Date:	June 10, 1991
Category 2	Organization:	Environmental Management

TITLE
LAND SURVEYING

Approved By:

______________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes procedures that will be used at the Rocky Flats Plant (RFP) to perform land surveying associated with all EM activities conducted by EMAD Accurate and dependable land surveying techniques are necessary to insure acquisition and documentation of data pertaining to the surface topography, geologic lithology, hydrogeologic and atmospheric regimes at the site Reliable land surveying data are essential to determining accurate areal and vertical locations of data acquisition (sampling) points and to tie these points into established map coordinates of the surrounding area This SOP describes procedures to be used during the preliminary placement of sampling points and land surveying requirements to accurately locate the points prior to, or after, the data acquisition event

3.0 RESPONSIBILITIES AND QUALIFICATIONS

Oversight and supervision of the sampling point location and land surveying operations will be conducted by an EG&G or subcontractor representative Preliminary location of the points may be performed by either EG&G or subcontractor personnel familiar with the project site and trained in the use of primary surveying equipment (e g. Brunton compass, tape measures, plumb bobs) However, the actual land surveying activities required to document the sampling point locations for the project record will be performed by a professional land surveying contractor The land surveying activities will be conducted by, or under the direct supervision of, a licensed Colorado Professional Land Surveyor

Prior to any land surveying operation, the EG&G or subcontractor representative will contact the manager and/or supervisory team leader of the surveying contractor to review the surveying program and supply the information necessary to complete the surveying program (e g list and location of wells or borings to be surveyed, approximate length and location of geophysical lines, etc.) Appropriate project-specific objectives presented in the work plans will be discussed at this time The subcontractor will have the ultimate responsibility for surveying data quality

4.0 REFERENCES

4 1 INTERNAL REFERENCES

Related SOPs cross-referenced in this SOP are as follows

- SOP GT 6, Monitoring Well and Piezometer Installation
- SOP GT 7, Logging of Test Pits and Trenches
- SOP GT 8, Surface Soil Sampling
- SOP GT 10, Borehole Clearing

5.0 PROCEDURES

5.1 PRELIMINARY LOCATION OF SAMPLING POINTS

The proposed locations of the data acquisition points will have been discussed in the project work plans with the locations indicated on project site maps/figures and/or described in the text EG&G and subcontractor personnel will review the proposed sampling points prior to actual location in the field and come to final agreement regarding them

Preliminary location of the sampling points prior to sampling will be achieved by staking and flagging the points These activities will, in most cases, be performed by the subcontractor and/or EG&G personnel and will attempt to achieve location accuracies of ± 10 feet of the proposed work plan data acquisition points Once the sampling activity is performed, the accurate location of the sampling point will be determined by precise land surveying methods

In the following example, a soil boring sampling point is to be established to obtain split spoon samples of suspected contaminated soils in proximity of an RFP Operating Unit The staking and flagging procedures employed for such a sampling event are representative of any data acquisition program at RFP and are presented herein to illustrate the generic procedures to be used in all EMAD/EM programs Predrilling staking and flagging will be performed as follows

A stake and orange flagging will be placed in close proximity to the preliminary sampling point location as identified on the project map If a more precise placement is dictated (such as to place a monitoring well directly downgradient of a buried pipe etc), a Brunton compass and steel tape will be used The predrilling site should be located within approximately five feet either direction of the map location and marked with a stake and orange flagging

If the preliminary location falls in an unfavorable site, a stake and green flagging will be placed in close proximity noting footage and direction to actual preliminary site location The EG&G project manager or designee will then make the determination as to final placement of the borehole and relocate the site with a stake and orange flagging. Each stake will have the borehole number clearly marked in permanent ink EG&G EM staff will field check each borehole location and approve the sites prior to the initiation of drilling.

The above procedures provide satisfactory site placement accuracy to conduct data and/or sample acquisition events All site measurements pertaining to location obtained during the event (i e , horizontal and vertical distance offsets) are subsequently related back to this staked location Land surveying methods, discussed in the next subsection, are then used to precisely tie the staked location into regional surveyed databases

NOTE It is critical that the flagged stakes used to preliminarily locate a data acquisition site be preserved intact during and after, the sampling event <u>until</u> the accurate land survey of the point is completed The stake represents the only historical reference point for the sampling event and must be protected If the stake must be destroyed during the sampling event (e g a soil boring or trench is placed at the staked location), appropriate offset stakes must be installed and documentation of the offsets (both horizontal and vertical) recorded in log books Once a sampling event is completed, the original staked location is reestablished and staked from this documented offset information

5.2 FINAL LOCATION OF SAMPLING POINTS

Before the final survey begins, the EG&G or subcontractor representative will contact the manager and/or supervisory team leader of the surveying contractor to review the surveying program Any information needed to complete the surveying program (e g list and location of sample sites to be surveyed, list and location of benchmarks to be used during the survey, site access, etc.) will be supplied Any other specific project objectives will also be discussed.

Instruments used for surveying will be recalibrated and recertified, if required The date of the last calibration and certification will be documented on the Surveying Form (Form GT 17A) The minimum relative accuracy for surveying will be 0 1 foot horizontally and vertically Monitoring wells may be located to the 0 01 feet in elevation because water level measurements are usually estimated to the 0 01 foot

Final location of the sample sites will be achieved by setting a marked stake with a tack in it at the exact location If a monument already exists, the location of the monument will be surveyed For abandoned borehole sites, the locating point will be at the center of the grout cap For well sites, horizontal measurements will be taken to the well center Three elevation measurements will be made the elevation of the grout or concrete apron adjacent to the north side of the well casing, the elevation of the top of the well casing and the elevation of the top of the protective casing All elevation measurements will be made on the north side of the well

All monument coordinates will be established by closed traverse, trilateration or other method that provides for verification of relative accuracy All monument coordinates will be reported on the Colorado State Planar Coordinate System (Lambert Projection, NAD 1927) Central Zone The coordinates will be true state plane coordinates All monument elevations will be established using at least two controls/benchmarks of known elevation Monument elevations will be reported according to USGS standards In addition, all monument locations will be checked by tying the site into a second known control/benchmark One benchmark will be east of RFP and the second benchmark will be west of RFP

6 0 DOCUMENTATION

A permanent record of the implementation of this SOP will be kept by documenting field observations and data The date of the most recent calibration and certification of the equipment will be documented Field calibration checks, surveying observations and data will be documented on the Surveying Form (Form GT 17A) A numerical printout of all coordinates and data provided on a 3 1/2" diskette along with a base map will be delivered to the EG&G or subcontractor representative within ten working days

U S DEPARTMENT OF ENERGY ROCKY FLATS

Form GT 17A

SURVEYING FORM

Project No ______________________ Date ______________________

Project Name ______________________ Weather Conditions ______________________

Site Location ____

____

Survey Purpose ____

Degree of Relative Accuracy Required ____

Equipment ____

Observations/Comments ____

____

SITE SKETCH

Remarks

Supervisor ______________________ Surveyor ______________________

Signature ______________________ Signature ______________________

Company ______________________ Company ______________________

SURVEYING
QUALITY CONTROL CHECK LIST

Surveyor shall check all items No 1 to 13 applicable to the surveying operation
Items unchecked shall be discussed and recorded in the "REMARKS" section
Items not applicable will be designated "N/A", the surveyor and supervisor representative will sign and date the checklist upon completion of the surveying operations and this checklist
Any additional comments should be included on the "REMARKS" section

GENERAL	**No.**	
Verification of survey sites	1	
Survey form heading completely filled out	2	
Abnormal or unusual conditions noted in "remarks" section	3	
Instrument calibration and certification verified	4	
Site location sketch completed or attached	5	
PRELIMINARY SURVEY		
Site located	6	
Site staked or flagged	7	
FINAL SURVEY		
Site coordinates recorded	8	
Site elevations recorded	9	
WELL SITES		
Elevation of grout or concrete pad recorded	10	
Elevation of top of well casing recorded	11	
Elevation of top of protective casing recorded	12	
CHECKS		
Site coordinates checked	13	
Site elevations checked	14	

EG&G ROCKY FLATS PLANT	Manual:	5-21200-OPS
EMAD MANUAL OPERATION SOP	Procedure No.:	GT.18, Rev. 0,D
	Page:	1 of 15
	Effective Date:	June 10, 1991
Category 2	Organization:	Environmental Management

TITLE
SURFACE GEOPHYSICAL SURVEYS

Approved By: ______________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes procedures that will be used at the Rocky Flats Plant (RFP) for conducting surface geophysical surveys In general, surface geophysical surveys will be conducted to aid characterization of the subsurface Geophysical techniques measure variations in the physical properties of the subsurface Thus, they are useful in identifying interfaces indicated by changes in seismic velocity, density, resistivity or conductivity, fluid content, degree of fracturing, soil or rock thicknesses, or linear features such as faults or dikes Since they measure physical property variations, geophysical techniques can aid the delineation of man-made subsurface features (pipelines or buried tanks, drums, and trenches) as well as subsurface contamination This SOP specifically addresses shallow electromagnetic (EM) and ground penetrating radar (GPR) techniques

3.0 RESPONSIBILITIES AND QUALIFICATIONS

Oversight and supervision of the geophysical surveys will be conducted by EG&G personnel The subcontractor project manager or task leader is responsible for assigning project staff to perform the geophysical surveys Project staff performing these surveys will be trained geophysicists or trained personnel with a significant amount of geophysical field experience The task leader is also responsible for assuring that these and any other appropriate procedures are followed by all project personnel

Only qualified personnel shall be allowed to perform geophysical surveys Qualifications are based on education, previous experience, or on-the-job training with supervision by another qualified person All staff involved with the geophysical surveys shall have previous experience with data collection and interpretation procedures for the methods used The subcontractor Project Manager shall document personnel qualifications related to this procedure in the project QA files.

4.0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references prior to the writing of this procedure

A Compendium of Superfund Field Operations Methods EPA/540/P-87/001 December 1987

Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERLCLA Interim Final October 1988

McNeill, J D. 1980 Electromagnetic Terrain Conductivity Measurement at Low Induction Numbers, Technical Note TN-6, Geonics Ltd , Canada.

RCRA Facility Investigation Guidance EPA Interim Final May 1989

4.2 INTERNAL REFERENCES

- SOP FO.3 General Equipment Decontamination
- SOP GT 10 Borehole Clearing

5.0 PROCEDURES

The use of geophysical techniques will be discussed in the project work plans Given the project-specific objectives and the subsurface information required, an appropriate geophysical program will be proposed and agreed upon between EG&G personnel and the subcontractor The purpose of the subsurface investigation and result expectations must be outlined Prior to the collection of geophysical data, several preliminary considerations must be made These include as a minimum

- Review existing and appropriate site, area, and regional subsurface geologic and hydrogeologic information including soil characteristics

- Define any known hazards that pose a threat to the safety of field personnel

- Review site utility plans and obtain the locations of electrical and telephone utilities and address their potential influence on survey results

Subsequent sections describe specific procedures for each technique

5.1 ELECTROMAGNETICS

5.1.1 Introduction

Electromagnetic (EM) methods provide a rapid means of measuring the electrical conductivity of subsurface soil, rock, and groundwater Thus, it can be useful for assessing subsurface conditions such as depth and orientation of bedrock; lateral variations in soil and rock and extent of paleochannels, lateral, and in some instances, vertical extent of contaminants, and the presence of ferrous and nonferrous metals

The method involves the induction of electrical current into the subsurface A small alternating current passing through a transmitter coil produces a primary, time-varying magnetic field into the ground Through inductive coupling, the primary magnetic field produces small eddy currents in the subsurface which, in turn, create their own secondary magnetic field The receiver coil senses both the primary and secondary fields Changes in magnitude and phase of the individual currents are linearly related to the terrain conductivity These changes in the individual currents are converted to voltages and output as ground conductivity values, which can be recorded manually, by a strip recorder, or a digital logger Depth of investigation is related to the separation between the transmitter and receiver coils By using multiple coil spacings, several penetration depths can be achieved All conductivity values are subsequently plotted on a map so that their variation over the site can be analyzed

Terrain conductivity is a function of the soil or rock composition, the porosity and permeability of the subsurface units, and the conductivity of the fluids filling the pore spaces The possible sources of an EM anomaly must be kept in mind when collecting the data and during interpretation

This SOP specifies procedures for EM surveys utilizing shallow penetration systems including the EM-31, EM-38, and EM 34-3 These instruments can be utilized with two different coil orientations, the horizontal dipole mode (coils vertical coplanar) and the vertical dipole mode (coils horizontal coplanar) The two modes provide different penetration depths to be achieved

5.1.2 Survey Design

5.1.2.1 <u>List of Necessary Equipment</u>

The following is a list of equipment that will be necessary to complete an EM survey

- Geonics EM-31, EM-38, or EM 34-3 terrain conductivity system or equivalent (choice based on depth penetration required)
- Digital logger and/or analog strip recorder (when data collection is over large grid area)
- Wood stakes or lath
- Flagging

- Field notebook
- Pens with nonwater-soluble ink

5.1.2.2 Field Procedures

A standard field procedure for collecting EM data is described below Prior to EM data collection, two preliminary procedures must be conducted These are

- Design appropriate field parameters, given the purpose of the survey, (depth of investigation, whether EM-31, EM-38, or EM 34-3 is used, coil spacing, coil orientation, station spacing, etc)

- **Survey the locations of line endpoints along each line and denote those locations in the field with lath or other wood stakes Mark stations with coordinate designation based on RFP coordinate system Transfer line and station locations to appropriate base map**

Design of appropriate field parameters must consider the following:

- The coil spacing should be 75 to 1.5 times the required depth of penetration depending on whether the instrument will be used in the vertical or horizontal dipole mode Instrumentation must be chosen so that the objective penetration depths can be achieved Table GT 18-1 summarizes instrument modes and approximate penetration depths

- Spacing between stations determines the degree of resolution achievable, a spacing of 10 to 100 feet is commonly used, however, spacing as small as 2 feet may be required for extremely shallow targets or to aid resolution in very complex environments

Actual chosen station spacing must be determined by resolution desired, maximum depth required, and overall survey objectives

- For grid areas, intraline spacing affects resolution, a spacing of 50 to 500 feet is commonly used However, smaller spacing may be required depending on the resolution required and overall survey objectives

- Accurate definition of an EM profile anomaly requires three or more anomalous readings

- Background conductivity noise caused by cultural interference, such as overhead or buried powerlines and steel-cased monitor wells, must be evaluated and/or estimated to assess their potential effect on an EM survey High noise levels can make interpretation difficult and can cause significant anomalies to be overlooked and, in some instances, can make data collection and interpretation impossible. Actual background noise must be considered when collecting and interpreting the EM data

- Background conductivities for the investigated materials or groundwater should be determined to aid anomaly interpretation Conductivities for site-specific groundwater should be determined by analyzing samples from monitoring wells adjacent to the survey area This should be done as close as possible to the actual survey date to ensure that the pore water conductivity determined is representative at the time of the survey

TABLE GT.18-1

EM INSTRUMENT MODE AND PENETRATION DEPTHS

Instrument	Coil Spacing	Mode	Approximate Depth of Penetration (ft)
EM-38	Fixed - 1 meter	HDM	2.5
	(3.28 feet)	VDM	5
EM-31	Fixed - 3.66 meters	HDM	9
	(12 feet)	VDM	18
EM-34-3	Variable - 10 meters	HDM	25
	(32.8 feet)	VDM	49
	20 meters	HDM	49
	(65.6 feet)	VDM	98
	40 meters	HDM	98
	(131.2 feet)	VDM	197

Note. HDM = Horizontal Dipole Mode
VDM = Vertical Dipole Mode

A standard field procedure for conducting an EM survey is described below.

1 Perform a visual survey along the proposed lines The visual survey will include a review of site utility plans, check for overhead wires, check for manhole covers, buried cables, buried gas line indications, or steel-cased monitoring wells, and have site locators confirm the presence of any possible telephone and utility features Note any features in field notebook

2 Note excessive amounts or large pieces of metal on the ground surface in field notebook

3 Note large nearby variations in topography or buildings (within 50 feet) in field notebook

4 Check instrument battery for sufficient charge and test instrument using manufacturer's procedures

5 Initiate site survey traverse with EM instrument Instrument operation must follow manufacturers operating procedures for horizontal and vertical dipole mode operation

6 Record the obtained conductivity value in the data logger, or field notebook Note station number and coordinates

7 Continue above procedure for each station along the line For two or more coil spacings or orientations at each station, multiple passes along each line are made, ensuring that occupied stations are repeated with each coil orientation

8 If hard copies of each line of data from strip recorder are made, label and/or number all notations made on the record to correspond to notes made in the field notebook

9 When a data logger is utilized, download data from the data logger on a daily basis to computer for further analysis

5.1.3 Data Processing and Interpretation

A standard procedure for processing and interpreting the EM data is described below

1 Collected data is downloaded from data logger or input to main computer from recorded field notes, and processed. Data is then plotted and may be contoured

2 Comparing the results of all plots, contrasts in conductivity may indicate the presence of subsurface anomalies

3 Using available borehole information and any other existing geophysical data as a reference, develop a subsurface conductivity model that is consistent with all available data

5.2 GROUND PENETRATING RADAR

5.2.1 Introduction

Ground penetrating radar (GPR) has been used for mapping shallow geologic interfaces, delineating shallow bedrock, locating voids in concrete or limestone, and finding buried pipeline or reinforcement bars

GPR involves a system that transmits electromagnetic pulses into the ground from an antenna near the surface These pulses are reflected from a variety of subsurface interfaces back to a receiver As the antenna is towed along a survey line, the GPR signals are processed and displayed on a graphic recorder. The displayed data is a two-dimensional continuous profile along the surveyed line, depicting time versus distance The display is very similar to a geologic section, except that the record is a time section rather than a depth section.

GPR has excellent resolution of subsurface features when favorable conditions exist However, actual depth penetration is highly site-specific and depends on the near-surface soil conductivity Highly conductive soils, such as clays, can reduce penetration to less than three feet Less conductive materials, such as limestone, will allow depth penetration of 30-50 feet

5.2.2 Survey Design

5.2.2.1 List of Necessary Equipment

The following is a list of equipment that will be necessary to complete a GPR survey

- GSSI SIR System-3 or equivalent digitally equipped radar system
- Flagging
- Lath or wooden stakes
- Field notebook
- Pens with nonwater-soluble ink
- Measuring tape (200 feet minimum) (note a measuring wheel can be substituted for relatively smooth surfaces)
- Extra paper for profile recorder
- Extra stylus(s) for profile recorder

5.2.2.2 Field Procedures

A standard field procedure for collecting GPR data is described below Prior to GPR data collection, two preliminary procedures must be conducted. These are

- Design appropriate field parameters, given the purpose of the survey (orientation of lines or grid, grid spacing, frequency of antenna, necessity of antenna shielding, etc)

- Survey in line endpoints and mark these locations in field with lath or wooden stakes Transfer line locations to correct position on base maps

Design of appropriate field parameters must consider the following.

- The antenna and associated transmitter frequency used must optimize the penetration depth and required resolution given the survey purpose Typical frequencies are 80 Mhz, 100 Mhz, 120 Mhz, 300 Mhz, 500 Mhz, and 1000 Mhz. Higher frequency antennas allow greater subsurface resolution, but penetration is reduced over that of lower frequencies Surveys should be designed to have a minimum of two antenna frequencies available, to optimize results

- For grid areas, intraline spacing affects resolution, a spacing of 3 to 50 feet is commonly used Actual spacing must weigh resolution required

- Method of antenna towing must be evaluated given the site conditions For smooth surfaces or terrain, the antenna can be towed directly on the surface For areas with significant vegetation or surface stones and rocks, the antenna may need to be suspended 6-18 inches above the ground or carried in a plastic non-conductive wagon, to prevent antenna damage and potentially dubious GPR data collection

- Antenna shielding should be considered and designed to handle the field conditions Surface features such as fences, powerlines, trees, etc can appear as prominent reflections on the GPR record

A standard field procedure for conducting a GPR survey is described below

1 Perform a visual survey along the proposed lines The visual survey will include a review of site utility plans, check for overhead wires; check for manhole covers, buried cables, buried gas line indicators, or cased monitor wells, and have site locators confirm the presence of any possible telephone and utility features. Note features in field notebook

2. Note excessive amounts or large pieces of metal on the ground surface in field notebook

3 Note large nearby variations in topography or buildings (within 50 feet) in notebook

4. Note moisture content of soil, alluvium, or investigated media, as well as relative clay content, as these could significantly affect the penetration depths

5 Conduct a test line using manufacturer's procedures Instrument settings must be optimized to obtain appropriate data given project goals Specific recording parameters that must be optimized include, but are not limited to, the following

- radar scan speed
- signal range gain
- high and low pass filter settings
- time range for recording
- transmitter pulse rate
- recording printer speed
- antenna towing speed

Instrument settings should be varied during the test line to determine the optimum recording parameters When possible, the test line should be conducted over a known buried feature in the survey area to help instrument setting optimization, and help calibrate penetration depths

6 Initiate site survey traverse Beginning at GPR line endpoint, tow antenna along line with appropriate speed determined from test line, and using optimum instrument settings determined from test line Continue above procedure for entire line and subsequent grid lines

7 If hard copies of each line of data from printer are made, label all notations on the record to correspond to notes made in the field notebook, including recording parameters

8 Permanent copies of this GPR data must be retained digitally on tape or disk, or on hard copy plots

5.2.3 Data Reduction and Interpretation

Data reduction of GPR data is limited Most of GPR data processing occurs with the various instrument settings during recording.

Interpretation must consider all potential sources of a GPR anomaly, including interfering reflections from both surface and subsurface cultural features, and draw upon the interpreter's GPR experience Using site surface data, available borehole information (should it exist), or any other existing geophysical data, develop a subsurface model that is consistent with all available data

6.0 DECONTAMINATION

Personnel involved with surface geophysical surveys will follow all decontamination procedures as outlined in the Health and Safety Plan Geophysical equipment which has been in contact with potentially contaminated ground surface will be decontaminated according to procedures outlined in SOP FO.3 - General Equipment Decontamination, as well as any appropriate procedures specified in the Health and Safety Plan

7.0 DOCUMENTATION

A permanent record of the implementation of this standard operating procedure will be kept by documenting field observations and data. Observations and data will be recorded with black waterproof ink in a bound weatherproof field notebook with consecutively numbered pages Documentation of completed decontamination activities should similarly be noted

FIELD GAS CHROMATOGRAPHS

EG&G ROCKY FLATS PLANT	Manual:	5-21200-OPS
EMAD MANUAL OPERATION SOP	Procedure No.:	GT.19, Rev. 0,FD
	Page:	1 of 9
	Effective Date:	June 10, 1991
Category 2	Organization:	Environmental Management

TITLE
FIELD GAS CHROMATOGRAPHS

Approved By:

______________________________ / /
(Name of Approver) (Date)

1.0 TABLE OF CONTENTS

2.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) describes procedures that will be used at Rocky Flats to define the standard operating procedure for the use of field gas chromatographs (GCs) These instruments are used in the identification and quantitation of volatile organic compounds

Level I and level II analyses are defined as field screening/analytical methods which utilize equipment amenable to the rigors of field conditions, and are located at or near the sampling site

Level I analytical support is typically defined as field screening, with the objective of generating data which will generally be used (for example during Phase 1 investigations), in refining sampling plans and determining the extent of contamination A second objective of Level I analyses is to conserve other analytical support resources

Level I analyses are generally effective for total Volatile Organic Compound (VOC) vapor readings using portable photoionization or flame ionization detectors (PID or FID) Detection is typically limited to volatile compounds These types of analyses provide data for on-site, real-time total vapor measurements, evaluation of existing conditions, sample location optimization, extent of contamination, and health and safety evaluations Data generated from Level I analyses are considered qualitative in nature although semi-quantitative and/or quantitative data can be generated, for example, by using the GC option of an FID, with sufficient calibration Data generated from Level I analyses provide the following

- Identification of soil, water, air and waste locations which have a high likelihood of showing contamination through subsequent analysis,

- Real-time data to be used for health and safety considerations during site investigations,

- Qualitative data relative to a primary calibration standard if the contaminants being measured are unknown,

- Quantitative data if a contaminant is known and the instrument is calibrated to that substance, and

- Presence or absence of contamination

Level II analytical support is designed to provide real-time data for ongoing field activities or when initial data will provide the basis for seeking laboratory analytical support As such, Level II analytical methods can be effectively utilized when a phased approach is used for field sampling There have also been a significant number of instances where data derived from Level II support have been used to make decisions about site disposition

Level II analyses are used for on-site, real-time baseline data development, extent of contamination and remedial activities and generally provide rapidly available data for a variety of activities including hydrological investigations (establish depth/concentration profiles), extent of contaminant determination including special activities such as vadose zone sampling, cleanup operations (determine extent of contaminated soil excavation), and health and safety considerations

Typically, a gas chromatograph and more sophisticated instruments operated in the field provide the bulk of the analytical support at this level The ability to assess the data quality (accuracy and precision) is dependent upon the QA/QC steps taken in the process, including documentation of blank injections, calibration standard runs, and runs of standards between samples, sample duplicates, and performance evaluation standards

The level of precision and accuracy that can be achieved by a specific Level I or II analysis varies as a function of numerous factors including the matrix and contaminant(s) being sampled, and the skill of the analyst doing the work

3.0 QUALIFICATIONS

Only qualified personnel will be allowed to operate gas chromatographs (GCs) Required qualifications vary depending on the activity to be performed In general, qualifications will be based on education, previous experience, and supervision by qualified personnel The subcontractor's project manager will document personnel qualifications related to this procedure in the subcontractor's project QA files

Operation of the gas chromatograph will be performed in accordance with the manufacturer's instructions Personnel performing gas chromatography will receive training from a factory representative or a local area instructor certified by the manufacturer to administer training.

4.0 REFERENCES

4.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure

Field Screening Methods Catalog. User's Guide EPA/540/2-88/005 September 1988

Chapman, H and Clay, P, Field Investigation Team (FIT) Screening Methods and Mobile Laboratories Complementary to Contract Laboratory Program (CLP), TDD HQ-8507-01, October 17, 1986 (Draft)

Clark, A E, Lataille, M and Taylor, E L, The Use of a Portable PID Gas Chromatograph for Rapid Screening of Samples for Purgeable Organic Compounds in the Field and in the Lab, U S EPA Region I Laboratory, June 29, 1983

Morin, S O, Development and Application of an Analytical Screening Program to Superfund Activities, Management of Uncontrolled Hazardous Waste Sites, Washington, D C November 4-6, 1985

4.2 INTERNAL REFERENCES

The related SOP cross-referenced in this SOP is

- SOP FO.3, General Equipment Decontamination

5.0 PROCEDURES AND EQUIPMENT

Equipment List

- Portable gas chromatograph with appropriate detector and accessories
- Chromatographic column(s) (project specific)[1]
- Vendor-supplied calibration standards (certified) and appropriate internal standards
- Glassware (project specific), including proper syringes
- Microprocessor and/or strip chart recorder with appropriate accessories and supplies (project specific)
- High purity specialty gases (project specific)
- Field log book

[1] Second column confirmation (dissimilar columns) if specified in Data Quality Objectives (DQOs)

- Instrument manufacturer's operation manual

All analyses shall be performed utilizing a field-area portable gas chromatograph (GC) A chromatographic column shall be utilized which separates target compounds An internal standard will be added to each sample being analyzed on the GC (including calibration standards) to ensure proper instrument performance

Prior to the start of analysis on each day, the GC shall be calibrated through the injection of commercially-available stock standards, and/or appropriate dilution of traceable stock standards This calibration (Initial Calibration) will, at a minimum, consist of the analysis of three standards with known concentrations The lowest concentration standard shall be at the required quantitation limit, the highest concentration standard shall be within the linear response of the instrument, and the middle concentration standard shall be approximately midway between these two A linear regression of the concentration of the standard against the chromatographic peak area shall be performed The correlation coefficient must be greater than 0 995

The GC calibration must be verified after every 10 sample analyses throughout the day Verification is accomplished through analysis of the mid-range concentration standard. If the measured concentration differs from the concentration in the standard by more than 15%, the GC must be recalibrated using the initial calibration procedures above

Samples are analyzed by injecting the same volume of sample into the gas chromatograph as was utilized during the calibration analyses Target compound concentrations in the sample will be quantified using the average response factor calculated from the initial calibration All sample analysis values must be less than the highest concentration calibration standard If a sample is analyzed containing a higher concentration than the highest standard, this sample must be rerun after dilution (alternatively, a smaller sample may be injected)

Specific analytical methods and calibration procedures, standards concentrations, detectors, temperature programs, etc are dependent on the method of analysis and analytes of interest Specific analytical methods and procedures will be detailed in applicable project work plans

Data Validation and Reporting

Data obtained from the use of the portable GC will be validated by qualified EG&G or subcontractor personnel Validation will include a review of the following specific parameters

- GC performance and calibration, including initial and continuing calibrations
- Qualitative and quantitative identification of analytes including recalculation from raw data of at least 15 percent of all sample data
- Analysis of field duplicates, field and method blanks, and spikes
- Referee laboratory (outside) duplicate analyses (if required)
- Duplicate analysis of field samples by on-site GC operator

A checklist used for validating data is included as Form GT 19A

6.0 DECONTAMINATION

Field gas chromatographs will be set up in the field site support zone in order to avoid contamination Field sample containers will be decontaminated in accordance with SOP FO.3, General Equipment Decontamination, prior to movement into the support zone and analysis using the field chromatograph Additional equipment used during sample analysis will also be decontaminated in accordance with SOP FO.3, General Equipment Decontamination

7.0 QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance (QA) and Quality Control (QC) activities will be accomplished according to the Quality Assurance Project Plan (QAPjP) and the project specific Quality Assurance Addendum (QAA)

In addition to adhering to the requirements of the site-specific Field Sampling Plan (FSP) and any supplementary site-specific procedures, the minimum QA/QC requirements for this sampling activity are the following.

- QC Samples -- The number and types of QC samples including duplicate samples, field blanks, equipment blanks, trip blanks, and other samples will be collected or prepared as specified in the QAA

- Verification -- Verification activities are required for the above practices, including surveillance and periodic record audits. These activities will be documented and become part of the completed project records.

7.1 QA/QC SAMPLES FOR FIELD GC ANALYSIS

Frequency of calibration, method blanks, replicates, etc , are dependent upon project Data Quality Objectives (DQOs), and must be addressed in the project-specific Quality Assurance Addendum (QAA)

Daily calibration and operational checks are required to ensure that the instrument is functioning properly Manufacturer's calibration instructions must be accomplished prior to daily use, and calibration must be confirmed at the end of each day The manufacturer's instrument operation manual will be present on site at all times

8.0 DOCUMENTATION

The field documentation requirements for the field sampler will include recording all observations made during the analysis that could affect the quality of the analysis The documentation for this analysis should be entered in a field notebook with consecutively numbered pages with locations identified on a sample location map

Field documentation should include at a minimum

- Date of sample collection
- Time of sample collection
- Location of the sample collected
- Sample number
- Unusual sampling conditions
- Problems encountered while obtaining the sample
- Each entry (or page) in the field notebook should be dated and initialed by the individual making the entry

U.S. DEPARTMENT OF ENERGY ROCKY FLATS

DATA VALIDATION CHECKLIST FOR GAS CHROMATOGRAPHIC ANALYSES

DATE ____________________

SAMPLES ANALYZED THIS DATE ____________________

____

____

ANALYST ____________________

DATA VALIDATOR ____________________

____

Answer Y = Yes, N = No where appropriate Y/N

I Calibration

A Was a 3-point calibration made at the start of the day? ________

B Was the correlation coefficient greater than 0 995? ________

C Was the GC calibration verified every 10 samples? ________

What standard was utilized for calibration verification? ________

Did the measured concentration differ by more than 15%? ________

If yes, was GC re-calibrated? ________

II. Blanks

A Was a method blank run immediately following the initial calibration and prior to any samples? ________

B Was any blank contamination present? ________

If yes, what was source of contamination and how was problem rectified? ____________________

____

C Were any field blanks run? ________

Any contamination present? ________

III Sample Documentation

A Were samples received in good condition? ________

If no, explain ____________________

____

B Were sample labels properly filled out? ________

If no, explain ____________________

____

IV Sample Analysis

A Were samples analyzed WITHIN required holding time? ________

If no, explain ____________________

____

B Were any problems encountered during analysis? ____________

If yes, explain ____

C Were target analytes detected above action level specified in DQOs? ____________

If yes, was identification & quantitation confirmed or second GC column if specified in DQOs? ________

Reference ____

D Were duplicates analyzed? ____________

If yes, what types ____

What was the relative percent difference (%RPD) between duplicates? ____

E Were any spike samples analyzed? ____________

What was result versus "true" concentration? ____

F Were any computation/transcription errors noted? ____________

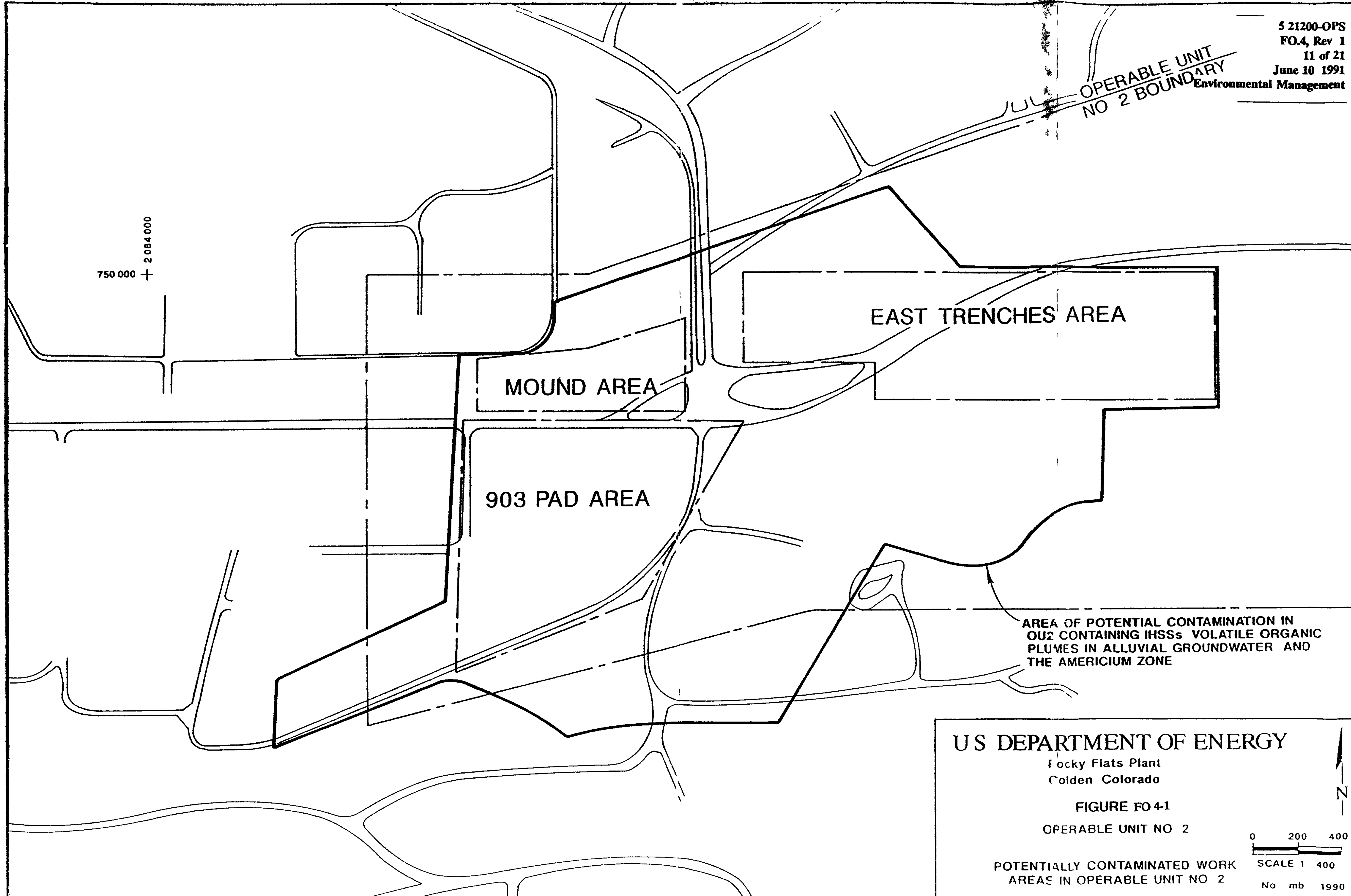
If yes, explain ____

G. Overall assessment? ____

H Notes ____

______________________ Analyst ______________________ Date

______________________ Data Validator ______________________ Date



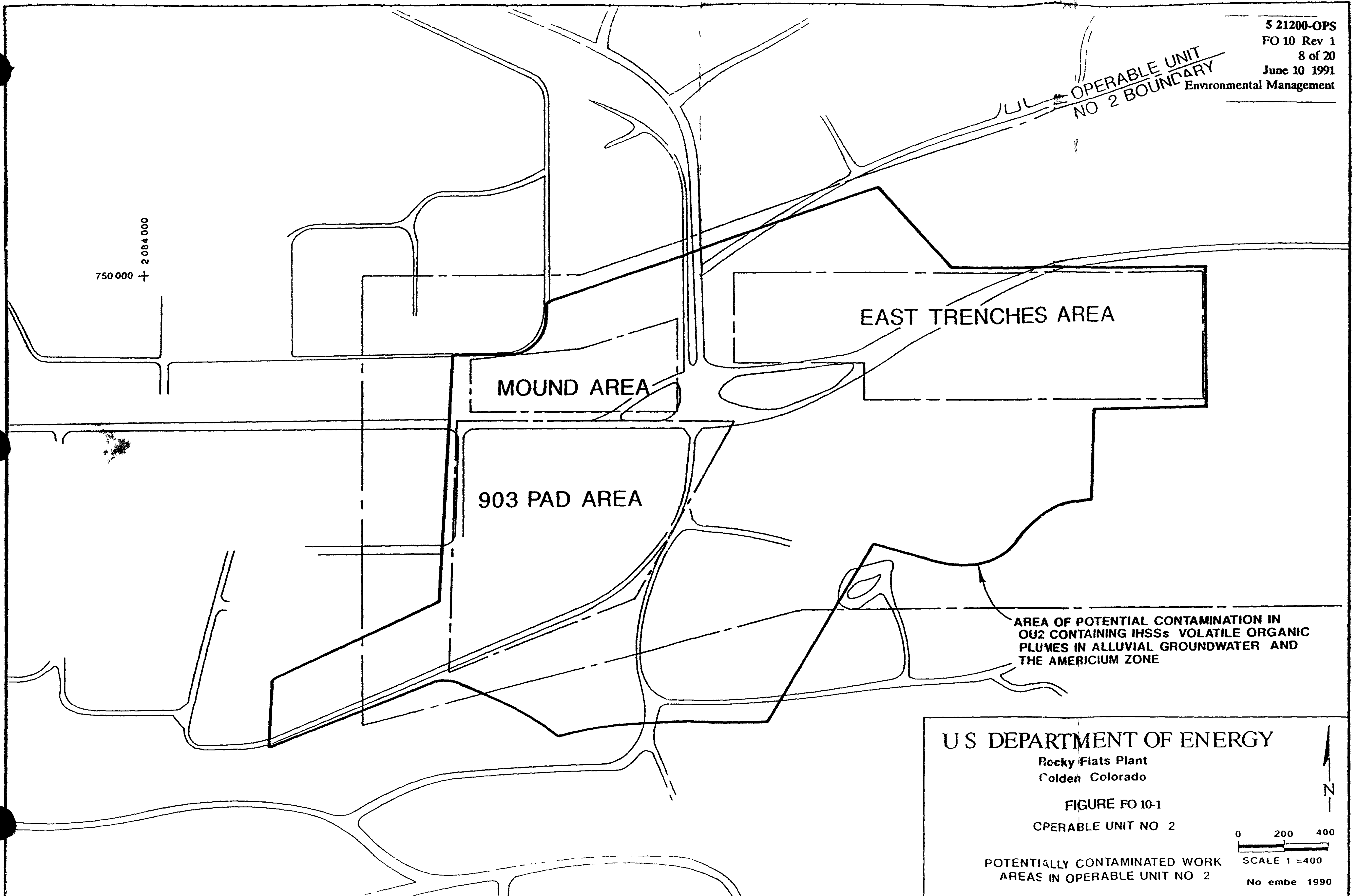
US DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden Colorado

FIGURE FO 4-1

OPERABLE UNIT NO 2

POTENTIALLY CONTAMINATED WORK AREAS IN OPERABLE UNIT NO 2

No mb 1990



U S DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden Colorado

FIGURE FO 10-1
OPERABLE UNIT NO 2

POTENTIALLY CONTAMINATED WORK
AREAS IN OPERABLE UNIT NO 2

No embe 1990